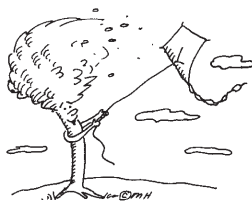


# The AMSAT<sup>®</sup> Journal

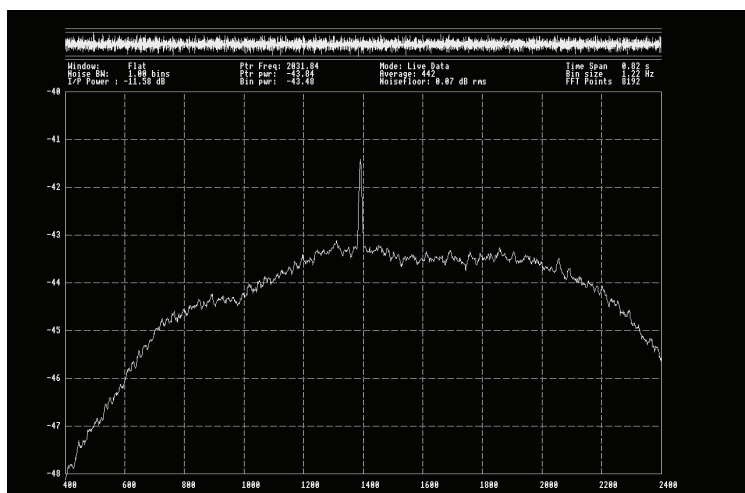


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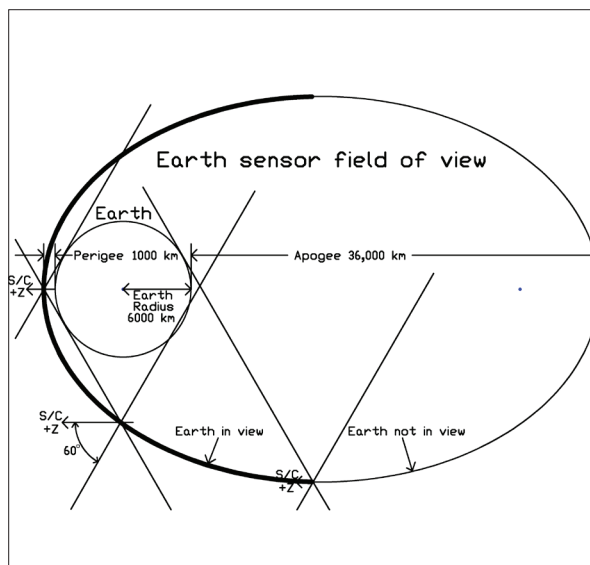
Editorial Staff:  
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Volume 29, Number 2

March/April 2006



**Amateurs successfully receive signals from Voyager 1.**



**Stabilizing Eagle.**

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### AMSAT Announcements

#### **NOTICE: AMSAT-NA Board of Directors Nominations Due No Later than June 12, 2006**

It is time to submit nominations for the upcoming open seats on the AMSAT-NA Board of Directors. A nomination requires either one Member Society or five current individual members to nominate an AMSAT member for the position. A director serves for a period of two years. Three directors' terms expire this year: Tom Clark, K3IO, Lou McFadin, W5DID, and Paul Shuch, N6TX. Nominations MUST be in writing and mailed to:

AMSAT  
850 Sligo Ave #600  
Silver Spring MD 20901

#### **Southwestern Division Convention**

I would like to invite everyone to attend the 2006 ARRL Southwestern Division Amateur Radio Convention to be held on September 22, 23, and 24, 2006 at the San Diego Marriott in Mission Valley.

The convention committee has been working diligently to provide a fun and interesting convention that has something for everyone. Please visit the convention Web site at [www.sandarc-conv2006.org](http://www.sandarc-conv2006.org) for details.

Note that the Early Bird Registration deadline is April 30, 2006. If you register prior to April 30, 2006, registration is \$15.00, which includes a convention pin (while supplies last). After April 30, 2006 Pre-registration is \$17.50 and an At Door Pass for the convention will be \$20.00.

Paul, KC6QLS  
Convention Assistant Co-Chair and Media Chair

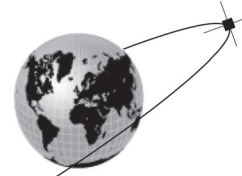
#### **AMSAT's Mission**

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

#### **AMSAT's Vision**

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.





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*The AMSAT Journal* staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to [journal@amsat.org](mailto:journal@amsat.org) using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

I felt honored to be present as an observer for the successful ARISS radio contact between Bowie High School (Maryland) and the International Space Station on Friday, March 17, 2006. Congratulations go to teacher Art Colton, KB3KAR, his students and the Goddard Amateur Radio Club, WA3NAN, for a job well done.

I find that the combination of Amateur Radio on human space flights and science education is a great way to introduce students and teachers to the wonders of Amateur Radio in an era of cell phones, Internet and instant messaging. The reaction of everyone in attendance to the first sound of an astronaut's voice as the space station rises over the horizon reminds me of the excitement I felt with my first contact as a ham over forty years ago. I hope that some of those students become hams one day.

AMSAT has been a sponsor of Amateur Radio on manned space missions (SAREX and ARISS) for many years, but our presence in schools, colleges and universities has been sporadic at best. I am hopeful that this will change with the appointment of Dr. H. Paul Shuch, N6TX, to the position of AMSAT Director of Education, a key part of the External Relations team led by AMSAT Executive Vice President Lee McLamb, KU4OS. Paul, who received his Ph.D. from the University of California, Berkeley, brings to AMSAT an extensive background in teaching, curriculum development, communications and engineering.

Among other things, Paul expects to work closely with Frank Bauer, AMSAT VP Human Spaceflight, to seek ways for AMSAT to follow up with ARISS schools and teachers to provide programs that will leverage their enthusiasm into an ongoing interest in math, science and Amateur Radio.

Paul also plans to add an education section to AMSAT's Web site and to start a regular column in the AMSAT Journal titled *The Orbital Classroom*. He would like to invite professional schoolteachers, professors, school administrators and curriculum developers within AMSAT's ranks to sign up as official AMSAT Educators so he can create a resource database.

## Coming Events

The Dayton Hamvention is May 19-21, 2006. AMSAT's booth will be bigger and better than ever and the AMSAT Forum on

Saturday morning will be an hour longer than in previous years. I look forward to meeting as many of you as possible. Please come by the AMSAT booth and introduce yourself.

It is not too early to start planning for the AMSAT 2006 Symposium, which will be held at the Crowne Plaza hotel in Foster City (near San Francisco) CA, October 6-8, 2006. There will be a Board meeting preceding the Symposium on Thursday and Friday to which AMSAT members are invited. The General Membership Meeting will be on Friday and the Awards Banquet with keynote speaker on Saturday evening. There will be exciting tours, door prizes, vendor displays and much more. You won't want to miss this year's Symposium, sponsored by Project OSCAR.

## AMSAT Needs You!

AMSAT needs your active support to achieve our goals, including our new education initiative, building and launching the P3E and Eagle satellites and our other projects. AMSAT must raise a minimum of \$150,000 in 2006 just for satellite construction activities. You can make a donation by going to the AMSAT Web store via our Web site at [www.amsat.org](http://www.amsat.org) or call Martha in the office at 301-589-6062. Donations of \$120.00 or more qualify for President's Club status where you may elect to have your donation payment spread over 12 months using your credit card as well as receive a special President's Club pin in recognition for your support of Eagle. Your generous contribution to AMSAT will help ensure that our common dreams will indeed become reality.

Other ways you can help include volunteering to set up an AMSAT table at your local hamfest, joining the Field Operations team, encouraging your ham friends and ham club members to join AMSAT, sending an annual contribution to AMSAT or giving a presentation at your local ham club. For more information contact me, the AMSAT office or any of your AMSAT officers or Board members by using the Web site's message forms by clicking on "About AMSAT" then "Our Leadership Team" then click on any name.

73,

Richard M. Hambly, W2GPS  
AMSAT President





# Potential Interference to the Galileo Global Navigation System from 23cm Band Operations

by Peter Blair, G3LTF, g3ltf@btinternet.com

### Introduction

This paper describes the proposed Galileo system design and its applications with particular reference to the E6 (1260-1300MHz) band. It covers some of the political issues driving the program and the frequency allocation situation. It describes the operation of typical receivers and their ability to deal with interference and gives practical illustrations of these effects. The likely effect of the Galileo E6 channel transmissions on 23cm receivers is analyzed and found negligible. However, there is the potential for 23cm transmissions to interfere unless the Galileo receivers are designed and built to withstand them when operating in the E6 channel. To work robustly in the expected electromagnetic environment, Galileo receivers will need to use the most advanced technology available. Finally, the likely course of events is discussed and arguments that we might use to continue our use of the band are presented.

### Galileo, History and Background

The Galileo program is intended to provide the European Union (EU) with its own Global Navigation Satellite System (GNSS). Currently there are two major systems, the USA's Global Positioning System (GPS) and the Russian GLONASS. GPS was designed as a military system and, until 2000, the open signal's accuracy was intentionally degraded. The US has now pledged to maintain the full capability, free, open service signals and will give six years notice of any change to this position. Although essentially a military system, civil applications have been wide ranging and are the basis of many businesses as well as supplementing and improving many existing navigation systems even though the users recognize that the US could degrade or jam the services should it judge that necessary for its security. GLONASS will not be discussed further, as it does not overlap our allocation and its future status is unclear.

Two programs have been implemented to overcome some of the deficiencies of GPS as they affect the civil aviation industry. These are the USA's Wide Area Augmentation System (WAAS) and the EU's European Geostationary Navigation Overlay System (EGNOS). Their purpose is to monitor the accuracy and quality of the GPS signals and provide an instantaneous warning via

geostationary satellite and data link should they degrade.

The EU view is that having its own GNSS is essential to its economic and infrastructure development and that it cannot rely on GPS for reasons of availability and reliability of the signals. Furthermore, GPS gives no performance guarantee. There is a benefit to both GPS and Galileo in having more satellites in space, particularly in situations such as cities where the view of the sky is restricted. Because both systems would operate in the same frequency band and with comparable modulation schemes, it will be relatively easy to build receivers to use all the satellites in view.

In 1999, after many years of studies of candidate systems, the EU launched the Galileo program. The definition phase ran from 1999 to 2001 and covered the definition of the architecture and services to be provided and the development and validation phase started in 2002. In this phase, the European Space Agency (ESA) will procure and launch two satellites, the first of which to be launched at the end of 2005. In 2007 the plan is to launch a mini constellation of four satellites to test the system in orbit. The cost of this phase is estimated as €1.1B and will be EU funded. The deployment phase, building and launching twenty six satellites and building and deploying the ground segment is estimated at €2.1B with two thirds coming from industry and the rest from the EU. Full commercial operation is still planned to begin in 2008 according to the Web site even though the award of the contract to the selected concessionaire is now not expected before the second quarter of 2006. The four principal countries involved in the work are France, Italy, Germany and the UK, all of whom will benefit under "juste retour" with jobs and the housing of ground facilities. Independent observers find this timescale unrealistic even without the usual funding delays and full operation in 2010 at the very earliest is probably more realistic.

The Galileo Joint Undertaking is, in essence, a body set up to organize the funding, the business plan and the risk sharing arrangements. Organizations of other nations outside the EU have been joining this body, most significantly from China and Israel. This will, of course, help with the arrangements

for hosting ground facilities outside the EU. In 2005 the Galileo Supervisory Authority was set up as an agency of the EU Commission to control and manage all aspects of the project including security and all technical matters.

### Galileo System Description

The system will operate in essentially the same way as GPS. Thirty satellites in 23,600 km orbits will carry atomic clocks and transmit accurate time signals using spread spectrum modulation together with orbit data and other messages. A receiver synchronizes itself to the satellites in view and by measuring the range to four of them can determine its position in three dimensions and obtain standard time. Higher quality receivers will use two or more frequencies making separate measurements to correct for ionospheric delay. The ground system, fully duplicated to provide resilience, will control the satellites through a series of uplink stations around the globe.

The services planned to be offered by Galileo are the following:

- The Open Service (OS) provides position and timing free of user charge.
- The Safety of Life Service (SoL) improves the open service by providing warnings to users when the OS fails to meet service standards.
- The Commercial Service (CS) provides access to two additional signals, which can provide higher data rate throughput and help to improve accuracy. It also provides a limited broadcast message capability from service centers to users.
- The Public Regulated Service (PRS) provides position and timing to specific users requiring high continuity of service with controlled access. Two PRS signals with encrypted ranging codes and data will be available.
- The Search and Rescue Service (SAR) will enhance the international search and rescue system by broadcasting globally the messages emitted from distress beacons.

There is little more than this available about the services because, of course, what is actually offered will be decided by those who are awarded the concession to develop and operate Galileo. Somehow the services have to generate an economic return in



the face of a free service (GPS) with long established applications world wide.

The latest published information, reference [1], on the mapping of the services to the frequency bands is from June 2003.

The three Galileo bands are as follows:

- E5 1164 - 1215 MHz carrying CS, OS and SoL
- E6 1260-1300 MHz carrying CS and PRS
- E1-E2-L1 (sometimes called L1) 1559 - 1591 MHz carrying CS, PRS and SoL

### **The Politics of Galileo**

It is important to understand a few of the key issues around the development and deployment of this system. It is being strongly backed by the European Commission as part of the drive to be independent of the USA. But because of its high cost (€3.2B to get it up and working is seen by some as an underestimate and, of course, the running costs are additional to this figure), it is essential to have industry involved in the funding in a Public-Private Partnership (PPP). The competition to choose the concessionaire to undertake the development and running of the system was terminated in early 2005 and the two contenders were asked to join forces and submit a combined proposal. The decision is now scheduled for some time in mid 2006. Obviously there is currently no information on what the concessionaire will offer; however, it is likely that there will be two income streams, one from the IPR involved in equipment licensing and one from the two subscription services, the CS and the PRS.

The fact that there is a free service already available from GPS, used for years by many companies to offer enhanced services for profit (e.g. differential GPS for oil prospecting and car navigation systems for example), must be a problem for the concessionaire. The open GPS signals are being enhanced by the addition of a second civil signal, called L2C, which will reach full operational capability (FOC) in 2010 and eventually a third wide bandwidth civil signal will be added. Furthermore, the existence of EGNOS and WAAS enhances the reliability of GPS for civil aviation and gives it much of what it wants without contributing to the costs of Galileo. Everybody would like the Galileo satellites to be available so that the coverage of GNSS, in urban canyons for example, would be improved, but no one wants to pay for them.

### **Is there a Requirement for a Galileo PRS?**

There are serious issues around the PRS concerning the extent to which it will be used, for example, by European government agencies such as customs and immigration or by the police and paramilitary. The advantage being put forward to these agencies is that PRS will offer a more secure service to them than the open GPS and that in the event that the open services of both Galileo and GPS were jammed to prevent their use by a hostile power, there would still be a service available. The encryption and other tricks on the PRS signal would also give protection against spoofing or meconing (see later). There is a cost involved however; both in new equipment and in user charges and the agencies will have to assess the costs against the risks. Some of the costs have probably not been recognized; for example the costs of certifying a police helicopter to use Galileo PRS rather than GPS as the input to its navigation system will be frightening.

There are also persistent stories that some countries wish to use the PRS for military purposes. While there would be no objection to using the Galileo signals for tracking material or for logistics purposes by peacekeeping forces, the application to weapon guidance would raise serious issues. Another factor often overlooked in the discussion of the PRS is that to make the system robust requires much more than just protection of the signal in space, it requires secure ground support facilities on a regional basis; this is costly. It all adds up to a lot of money to pay for independence of the US system which is well established and which, with the second civil frequency added in 2010, will have a high level of robustness.

The recently published report of the UK House of Commons Transport Committee, reference [2], voiced serious concerns about the PRS - "The uses described for the PRS are hazy; the UK government has said it does not want to use it... The Committee urges the UK government to ensure that there is a real demand, that access can be properly controlled and that it would not allow the use of PRS for military applications".

This situation will not be resolved or even clarified until the Concessionaire's contract is available for examination. This will be a costly program whichever way it is funded.

### **The Frequency Allocation Situation**

At the World Radiocommunication Conference in 2003, (WRC-03) a primary status allocation was approved with no power flux-density (pfd) limits for the radio navigation satellite service (RNSS) in the 1260 -1300 MHz band. The allocation was a result of studies conducted since WRC-2000 on sharing between RNSS and the radiolocation service in this band. The WRC invited interested parties to continue appropriate technical, operational and regulatory studies (including an assessment of the need for a pfd limit) on RNSS systems in the 1215 to 1300 MHz band. The purpose of the studies was to ensure that the RNSS would not cause harmful interference to the radiolocation (radar) service. All studies were to be conducted as a matter of urgency and in time for WRC-07. They are reported under WP 8B. There is a possibility for radar targets to be obscured by the signal from a Galileo satellite because the high gain of the radar antenna and tests carried out in the USA on working radars have demonstrated the potential problem, reference [3]. Some proposed measures to achieve compatibility include tailoring the RNSS signal to reduce overlap with the radar band, pfd limits on the RNSS signal and frequency separation. It is clear from the material already submitted to WP 8B that the USA is concerned about interference to its L-band ATC radar network, however many countries operate ATC and defense radars in this band so it is a much wider problem. Wind profiling radars operate in the band 1270 to 1290 MHz and a recent study examined the level of protection that these would require in the presence of Galileo E6 signals.

It should be noted that the WRC appears to wish to achieve a mode of operation and spectrum sharing in which up to five separate satellite GNSS systems can operate in the allocated spectrum 1215 to 1300 MHz. The Galileo organization's stated essential requirement is to have the same regulatory regime in the whole of the band and to achieve regulatory protection of all radars through a footnote in the Radio Regulations. The position of the International Civil Aviation Organization (ICAO) is "To support the incorporation of a single regulatory mechanism applicable to RNSS in the whole band 1215-1300 MHz as a necessary protection for important radars used for civil aviation purposes, and to support the incorporation of the agreed



mechanism within an adequate regulatory framework having full mandatory force for current and future RNSS systems". The challenge to Galileo was to get a satellite up and running by April 2006 to claim the frequency allocation. This was achieved, on schedule, on December 28, 2005 by Giove, the satellite built by Surrey Satellite Technology Ltd. (SSTL). The satellite carries a number of pieces of equipment, such as atomic clocks, for trial purposes. The radiated frequencies are not known but it is believed it is also able to monitor the radiation environment, but whether this includes the radio spectrum is unclear.

### Potential Interference from Galileo to 23cm Amateur Operations

The Galileo signal at the earth's surface is very weak and spread over a wide bandwidth, and will only be a source of interference to EME stations with large antennas. As a typical 23cm EME system uses a large, typically >3m, antenna, the satellite will only be present in the beam for a short time.

The Galileo PRS signal is planned to be -128dBm as received by a *right hand circular polarization* (RHCP) antenna and spread over 40 MHz. A 3m dish has 30dBi gain and a typical receive sensitivity would be -152dBm for a 500 Hz bandwidth. The bandwidth restriction means that the received power is -128dBm - 49dB = -177dBm. The antenna gain increases this to -147dBm. However, fortunately the EME standard is for *left hand circular polarization* (LHCP) on receive and so there is an additional attenuation of the cross polarization performance of the dish and feed, typically 20dB. Thus the operator will not experience a noise increase. With a 10m dish the increase will just be noticeable. There is a further factor to be considered and that is the spectrum shape of the Galileo signal: this tapers towards the band edges and so there is a further (estimated) 6dB reduction in the noise received. Systems using noise measuring receivers to measure moon noise (for dish pointing or system calibration) or to observe radio stars in this band will be more adversely affected. For example a 500 kHz wide receiver with a 10m dish and receive system would see a noise increase of about 30dB as a satellite went through the beam which would make it virtually useless.

### The Operation of GNSS receivers and their Typical Response to Interference.

To assess how amateur transmissions

might interfere with Galileo receivers it is essential to understand a little about how these receivers might operate and about their capability to reject interference.

The signal structure of GPS and Galileo is similar and so the receiver characteristics of both will also be similar. A receiver has to lock onto the satellite's carrier frequency, with correction for the Doppler shift, and synchronize its code generator to that of the particular satellite that it is receiving. The code is modulated onto the carrier by a process of phase reversals. When the receiver has achieved carrier lock and code synchronization, it is able to effectively make a measurement of the distance (called a "pseudo-range"), between the satellite and the receiver. A separate signal (in Galileo) also carries data giving the satellite orbit and other essential information which the receiver then decodes. When the receiver has gone through this process with four satellites, it is able to calculate its 3D position and velocity, and its clock is synchronized to the system standard time. Measurements to additional satellites will improve the accuracy of the measurements and provide resilience against intermittent loss of signal. Modern GPS receivers perform some of this process in digital form: in five years time virtually all of it will be digital. When a receiver is tracking a signal from a satellite the bandwidth of the code and carrier tracking loops can be very narrow. The code loop might be as low as 0.1Hz, the carrier loop 1kHz or less. The satellite's motion is highly predictable and so a stationary receiver, once the carrier is locked on, can easily follow the Doppler change. However, if the receiver is moving, for example in a vehicle, then a sudden change of direction could cause the carrier loop to lose lock. To prevent this, either the receiver must allow the loop to operate at a wider bandwidth or the tracking loop must be "aided" by inputs from another sensor. In a fighter aircraft, for example, this aiding comes from the inertial reference system. In a vehicle it could come from a much simpler low cost gyro or dead reckoning system. These forms of coupled sensors are expensive. It is obvious from the foregoing that while a receiver is in tracking mode with the carrier and code operating as narrow bandwidth loops, it has a high ability to reject interference due to the narrow bandwidths. The loop characteristics are similar to a flywheel and a short interruption of one or more signals can be accommodated by the

receiver. There are many techniques that can be used to extend the ability of the receiver to keep tracking the satellite(s) in the presence of interference. Some examples are:

- Tracking the code alone if the carrier lock is lost.
- A dual frequency channel receiver may continue to track if the second channel is not affected by the interference.
- A narrow band filter can be automatically steered in the processor to reduce the effect of a CW interferer.
- Pulsed interference can be reduced by pulse blanking.
- The use of multiple correlators, some new receiver chip designs use over 2000 to enable the signal to be tracked through fades and interference.
- Antenna nulling - a further significant increase in the ability of a receiver to withstand interference comes from the use of an adaptive antenna which can automatically steer nulls onto multiple sources of interference. It is possible to obtain 30dB of improvement with this technique.

Where receivers are most vulnerable is in the acquisition phase. If a receiver starts absolutely from scratch, i.e. unknown position, velocity and time (PVT), then it will have to search with wide loop bandwidths to find the signal and lock to the code. The more information it has about its PVT the faster it can acquire and the narrower the loops can be. Once a receiver is giving good PVT data then it is more difficult to interfere with, or jam. Where problems can arise is when the receiver is forced into a re-acquisition mode and where interference prevents it from then re-acquiring.

There is, obviously, a vast difference in receiver performance between those designed for leisure walking and those designed for civil aviation or for the most demanding military environments. A simple small receiver does not have the room for quality front end filtering or high dynamic range for example.

Finally, spoofing must be mentioned. This is a technique for interfering with GNSS operation by transmitting either a simulated signal or a delayed version of a real signal with the aim of making the receiver display an incorrect position. In the proposed PRS it is intended to include cryptographic techniques to prevent this abuse.



## Practical Interference Scenarios

This section will examine some interference scenarios. The Galileo E6 signal is -128dBm as received by an isotropic circularly polarized antenna and in total has a 20MHz bandwidth. That means it is roughly 30dB below thermal noise before signal processing. The Martlesham beacon on 1296.835MHz has an quoted ERP of 700W (58dBm) referenced to a dipole. The code modulator in the receiver operating at 5 Mchips/sec effectively turns this CW signal into a noise spectrum at its output so that if the receiver is tracking with, say, a 100Hz bandwidth, there is a processing gain (2x chip rate/tracking loop bandwidth) of 50dB. The tracking loop will continue to operate with an interferer about 5dB above the wanted signal. We will assume that as the beacon is near the upper E6 band limit and that the receiver matched filter attenuates it by 6dB. There is a further 3dB attenuation as the Galileo receiver has a CP antenna. The margin required to continue operating is then  $-128 + 5 - (58 - 50 - 6 - 3) = -122\text{dB}$ . This attenuation occurs at a range of 18 km. The approximate radio horizon of this beacon is 35km (there are a number of assumptions in this calculation but it indicates the scale of the potential problem).

A pertinent question, (perhaps even an FAQ) is ... "so why hasn't this problem occurred with GPS which has been in use for a decade or more?" The answer is that the simple GPS L1 (1575.42MHz) receivers are, indeed, vulnerable to interference but that their (approximately) 2MHz wide frequency channel is clear because it is protected to aeronautical standards. These receivers can be disrupted by relatively simple jammers, designs for which are available over the Internet but there are few reported instances of problems.

The study, completed in 2001, of the vulnerability of the US transport system to GPS failures by the USA DoT's John A. Volpe Transportation Systems Center, reference [4], states that a 1W CW airborne jammer would break lock in a typical receiver at 10km and prevent lock at 85km. A jammer, which more accurately mimicked the GPS waveform would be effective to > 900km. Other potential sources of interference are the harmonics of VHF/UHF base stations and mobiles which are stated to have been shown to deny operation out to 9km. It is noted that the fourth harmonic of the new Tetra deployment at 390MHz falls in band).

A study of interference to Civil GNSS applications by out of band interference has been undertaken for the Australian Global Navigation Satellite System Coordination Committee, reference [5]. Testing of the performance of typical GPS receivers in the presence of potential interference sources was carried out using commercial receivers. The study concentrated on interference affecting the GPS L1 signal and it looked, in particular, at the possibility of interference from the harmonics of UHF TV transmitters to GNSS. By a mixture of measurement and simulation the study determined that the typical third harmonic radiated from a 480kW TV Transmitter would disrupt GPS operation over a 3.5 km radius. There are plenty of high power TV transmitters in the UK whose second and third harmonics fall on the L1 frequency, but the writer has not heard of problems being reported.

At the other end of the scale there is a report of a 2mW jammer disrupting GPS operation over a 1 nautical mile radius in a sea trial. This would represent about -100dBm at the receiver, exactly the level predicted by theory. In the lower part of the GNSS band both GPS and GNSS have to cope with the pulsed signals from the aeronautical distance measuring equipment (DME) and from TACAN and JTIDS / MIDS which are pulsed navigation systems and data links respectively. In addition, Galileo receivers will have to cope with the navigation radars in the E6 band and their out of band transmissions as well. In a paper, reference [6], to be presented at the 2005 ION NTM Conference, the problem is highlighted but the solution is not obvious. For an excellent description of the GPS C/A code receiver jamming issue see reference [7].

### What is likely to happen?

There is no doubt that GNSS will play an increasingly important, if not essential, role in the transport infrastructure operation in both Europe and the USA. The EU seems determined to possess its own system, independent of the USA and GPS. However it still remains to be seen whether it can get the private sector to finance and run it for profit or whether it will have to heavily subsidize its operation. All NATO countries have access to GPS and so, in the light of other priorities for military equipment spending, it seems very unlikely indeed that there would be pressure from the European military for an independent system, especially when

the US have said they would jam it, (or worse!) if it were perceived as a threat. The Galileo funding issue is not yet settled for development or for operation.

If Galileo goes forward as planned, with a year or two delay, then as its usage becomes a more integrated and critical part of the infrastructure, the demand to have greater security, availability and reliability from the service will grow. This is happening already in the USA as the planned use of GPS for aircraft precision approach and landing comes closer to realization. Air transport is more important in their infrastructure and so there is a need to see a way through to a highly robust civil GPS system.

The report by John A. Volpe, Transportation Systems Center, reference [4], reviewed this area and made many recommendations for improving robustness and availability, including research into interference mitigation and interference location. Everyone is beginning to recognize that the current GNSS *does* have vulnerabilities and that interference mitigation has to be an important and necessary component of the receiver system design where these are to be used in crucial systems.

Even if Galileo does not proceed we have to recognize that the 1260-1300MHz band will be used *at some time* for GNSS and that these systems will always have a rather weak signal at the earth's surface. Sharing the allocation with radar is/was relatively painless for the amateur services. Radars, even civil ones, are designed to cope with interference by employing a whole library of techniques developed over many years. Furthermore, because the number of radars is small and they are large installations and easily physically protected, the techniques can be kept secret where necessary. Although there are some who are calling for these bands to be effectively swept clear of interference sources this is (in my own view) impractical, especially where they are not protected by the stringent aeronautical regulations. Therefore if it is required to have a robust PRS service in the E6 channel then those receivers will have to incorporate *very extensive* interference rejection measures. The limit will be set by what can be released from military anti-jam technology into this para-military area, bearing in mind the virtual impossibility of keeping large numbers of the PRS equipments secure.



## What can the Amateur Services Do About It?

While Galileo might be delayed, it is unlikely to be stopped, although it is a possibility. Even if it is, then at some time (probably post-2007) another GNSS will take the allocation. This might lead to some limitations on continuous transmissions such as beacons, TV repeaters and FM repeaters below 1300 MHz.

Non-continuous signals such as SSB/CW ought to be much less of a problem to a robust PRS receiver and one can argue that 23cm amateur transceivers will be available for many years to come and probably constitute the largest quantity of potential jammers available to any person or organization wishing to cause disruption. Therefore the PRS receivers should protect against them and therefore we should be allowed to continue.

We must argue that, to a moving vehicle, the signal from a typical amateur SSB/CW transmission will be very intermittent and therefore the receiver should be little affected by it. It would be useful to take some measurements of these sorts of signal levels. Obviously the terrain masking effect would be less for the police helicopter scenario but it would still be present to a degree.

EME operations are typified by a higher ERP than normal "tropo" stations. However, the beam widths are small and so the duration of interference is short and a well designed receiver in a police helicopter for example would "flywheel" through it. The side lobe levels are about the same ERP as a tropo station and the antennas, being large, are at low height, which considerably increases the intermittency of the signal at a distance. Similar considerations apply to satellite operations in the 23cm band which take place in the 1260-1270 MHz sector.

Much will depend on what arrangement is worked out to protect the radar operations, what is worked out at WRC-07 for both radar and Galileo E6 receivers to continue to operate. As someone said to the writer, "the radar guys will do the heavy work on this issue."

At the IARU region1 meeting at Davos in September 2005 a similar paper to this one, C5.13, was presented by the RSGB but no actions were placed. In my opinion it would be useful in formulating our case to remain in the band if we had more information about the following issues:

Which nations have definite plans to use the E6 services and for what applications they anticipate it being used.

Which nations have ATC radars operating in that band and whether they have plans to change them in response to Galileo.

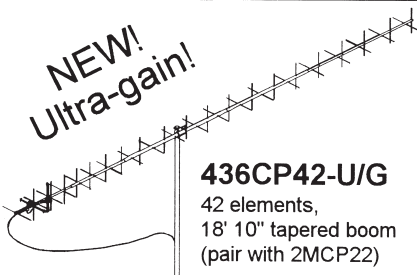
It seems to me that Galileo receivers which are robust enough to coexist with ATC radars should also be able to cope with intermittent amateur signals.

## References

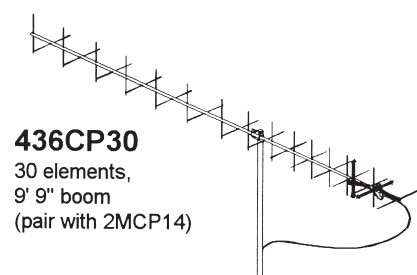
- [1] J-L Issler, G Hein, J Godet, et al. "Galileo Frequency and signal Design", GPS World, June 1st 2003. See <http://www.gpsworld.com/content>
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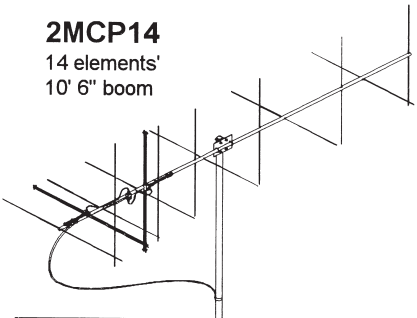
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**Ultra-gain!**



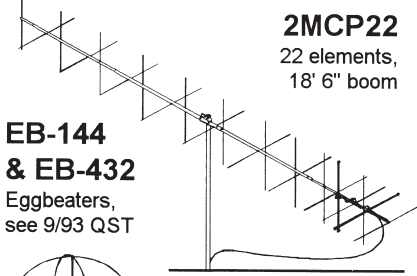
**436CP42-U/G**  
42 elements,  
18' 10" tapered boom  
(pair with 2MCP22)



**436CP30**  
30 elements,  
9' 9" boom  
(pair with 2MCP14)

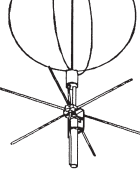


**2MCP14**  
14 elements'  
10' 6" boom



**2MCP22**  
22 elements,  
18' 6" boom

**EB-144  
& EB-432**  
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AMSAT is the North American distributor of **SatPC32**, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP.

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- Interfaces with WiSP, with user-defined satellite switching priority.
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A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>. A registration password for the demo version is \$40 (members), \$45 (non-members).

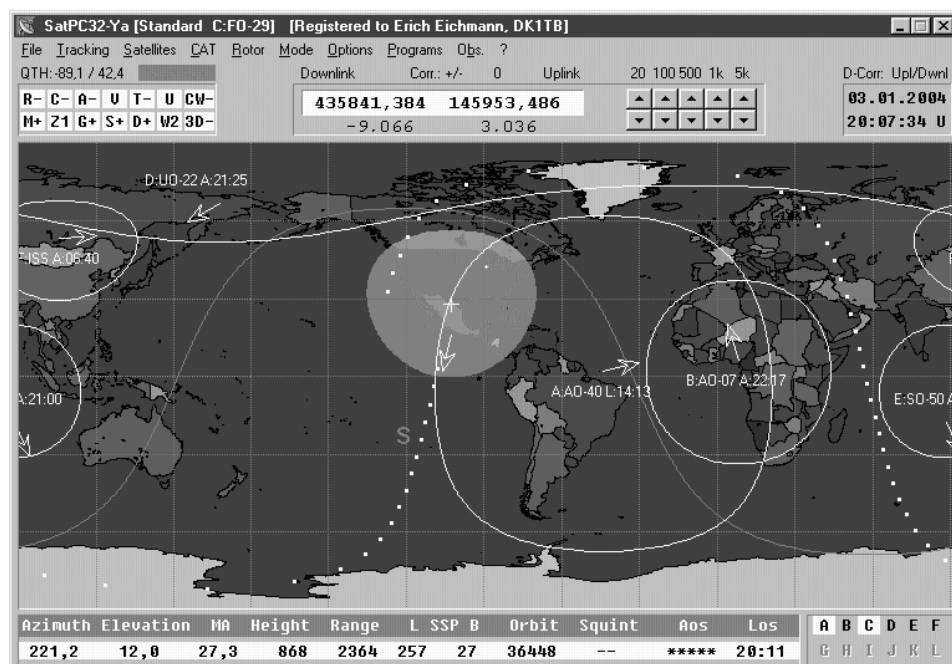
Order by calling 1-888-322-6728, or use the online shop at [www.amsat.org](http://www.amsat.org). The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.



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## Satellite Signals and Reception, Part I

Gould Smith, WA4SXM, wa4sxm@amsat.org

The first advice I give new satellite users has long been "Put together the best receive station you can." If you follow this advice, everything else will be much easier. Generating an adequate 2M or 70cm signal to the satellite requires very little power. Most LEO satellites transmit less than 1W, so even a hand held radio transmits a signal that is 3-5 times the power the satellite is downlinking. This column and the next one will look at why you need to optimize your satellite receive system. All of the commercial FM/SSB receivers available today will give you quite good results if you give them a good signal. We will look at satellite reception in two parts: Part 1 – signals from the satellite to the antenna and Part 2 – The antenna to your receiver.

Those new to amateur satellites may expect the same operational experience as they are accustomed to terrestrially. What I mean is that if you have worked 2m and 70cm repeaters with your handheld and you are using the same handheld for satellite operations, then you might expect the same signal levels. But this will not be the case. Most terrestrial repeaters are at the higher locations in the area served and generally run 20 to 35 Watts. The height and power are the major factors in your good reception. The height provides an increased line of sight and wider coverage area. These are important for VHF/UHF work. The power gives you a stronger signal to attenuate. A generally

accepted formula for terrestrial repeaters is  $\text{radio horizon}_{\text{miles}} = \text{SQRT}(2 * \text{height}_{\text{feet}})$ . Coverage from the ground to average repeater heights are found in Table 1. These are typically about 15% further than line of sight. These are best case numbers and don't take into account obstructions and atmospheric conditions.

Coverage from space uses a different formula because there is essentially no atmosphere (formula 13.2 from *The Radio Amateur's Satellite Handbook* by Martin Davidoff, K2UBC. Table 2 gives you some representative coverage areas from a satellite transmitter.

So here mathematically you can verify what you have experienced. It is easy to understand the difficulty in using 2m/70cm simplex while walking or driving, and the extended coverage opportunities when portable on a mountain. Obviously satellites open up a wider coverage area. So many people have simultaneous access that this often creates quite a challenge to those trying to operate single user FM repeaters. You can see that AO-51 at about 800 km altitude will allow about a 3777 mile diameter footprint – nearly all of North America, see Figure 1. While AO-7 at a higher altitude of 1450 km gives you an even larger footprint, allowing the Eastern part of the US, Canada and the Caribbean to talk with Western Europe and Africa, see Figure 2.

## Path Loss

Alas, the benefit of height comes with a tradeoff that you generally don't notice terrestrially – path loss. Electromagnetic waves experience quite a loss as they propagate through space because the wave disperses with the square of the distance from the source, known as the inverse square law -  $\text{Intensity} = 1/d^2$ . If you measure a signal at 1 km and at 10 km you will find that the signal at 10 km is only 1/100th as strong as at 1 km due to path loss; see Figure 3. An integral part of discussing path loss involves dB. So, let's review decibels before we continue with path loss.

## dB or decibel

You have seen dB values referenced for many types of equipment. A dB or decibel is  $1/10^{\text{th}}$  of a bel (abbreviated B). The bel is named after Alexander Graham Bell and initially was used to measure sound energy. Since our ears respond to such a wide range of sounds (a range covering about  $10^{-4} - 10^{-16} \text{ W/cm}^2$ ), it is best to use logarithms to represent these values. Rather than using a scale of one billion, we can use a range of 12. The bel value is unlike many that you are familiar with like volt, ohm, kilogram because it doesn't measure a fixed quantity. Instead it is used to describe the ratio between two values. Bels can also be used to compare electrical power levels. The logarithm of a power ratio is defined as a bel. The equation looks like this:  $\text{bel} = \log(P_1/P_0)$ , where  $P_0$  is the reference power and  $P_1$  is the power you are comparing it to.

Since it takes 10 decibels to equal one bel, the equation for decibels is:

$$\text{dB} = 10 \log(P_1/P_0).$$

For a practical example, let's say we want to determine how many decibels an amplifier increases the power output. If we insert a 1W signal into the amplifier and get 35W out, the equation becomes  $\text{dB} = 10 \log(35/1) = 10(1.544) = 15.44 \text{ dB}$ . So the amplifier has a gain of 15.4 dB, even though its output power is 35 times the input power.

Now there is quite a bit more to decibels but, I am just going to talk about some of the more common relationships and the ones I feel you should be familiar with. The first one is doubling or halving the power. The dB increase for doubling the power is the same whether it is going from 1W to 2W, 5W to 10W or 35W to 70W.

Table 1: VHF/UHF terrestrial coverage distances by height (distances rounded).

| Antenna Height<br>in Miles | Antenna Height<br>in km | Antenna Height<br>in Feet | Coverage Radii<br>Miles | Coverage<br>Diameter Miles | Standard<br>Terrestrial<br>Heights |
|----------------------------|-------------------------|---------------------------|-------------------------|----------------------------|------------------------------------|
|                            |                         | 5                         | 3                       | 6                          | Standing                           |
|                            |                         | 15                        | 5                       | 11                         | Single Story<br>Rooftop            |
|                            |                         | 25                        | 7                       | 14                         | Two Story<br>Rooftop               |
|                            |                         | 100                       | 14                      | 28                         | 10 Story Building                  |
|                            |                         | 300                       | 24                      | 49                         | FL Repeaters                       |
|                            |                         | 1000                      | 45                      | 89                         | Nice Round<br>Number               |
| .62                        | 1.0                     | 3,281                     | 81                      | 162                        | East TN<br>Repeaters               |
| 1.2                        | 2                       | 6,562                     | 100                     | 199                        | Eastern US<br>Repeaters            |
| 6.2                        | 10                      | 32,804                    | 256                     | 512                        | Commercial<br>Airplane             |



**Table 2: Satellite coverage distances.**

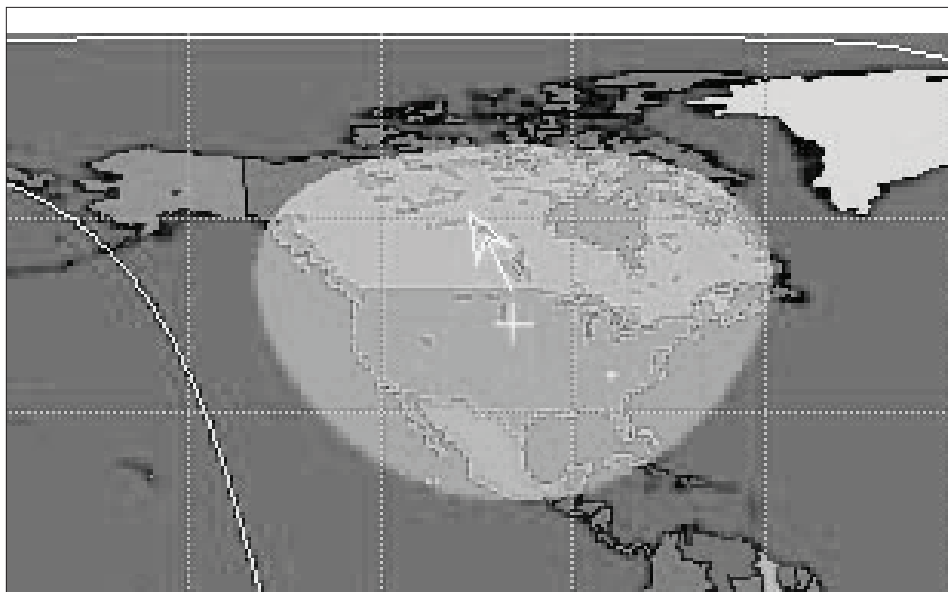
| Antenna Height<br>in Miles | Antenna Height<br>in km | Feet        | Coverage Radii<br>Miles | Coverage<br>Diameter Miles | Structures and<br>Satellites at<br>this Height |
|----------------------------|-------------------------|-------------|-------------------------|----------------------------|------------------------------------------------|
| 229                        | 369                     | 1,210,628   | 1,317                   | 2,634                      | ISS                                            |
| 310                        | 500                     | 1,640,417   | 1,520                   | 3,040                      | Eagle Perigee                                  |
| 497                        | 800                     | 2,624,667   | 1,889                   | 3,777                      | AO-51, AO-27                                   |
| 746                        | 1200                    | 3,937,000   | 2,260                   | 4,521                      | FO-29                                          |
| 905                        | 1456                    | 4,776,894   | 2,455                   | 4,910                      | AO-7                                           |
| 21,748                     | 35,000                  | 114,829,176 | 5,612                   | 11,224                     | Eagle Apogee                                   |

$\text{dB} = 10\log(2) = 10(0.301) = 3 \text{ dB}$ , so doubling the power is always a 3 dB increase.

Reducing the power by half:  $\text{dB} = 10\log(0.5) = 10(-0.301) = -3 \text{ dB}$  decrease.

$0.0625\text{W} \rightarrow 0.03125\text{W}$  or  $31\text{mW}$ ] In dB terms this is  $(-3 \text{ dB}) + (-3 \text{ dB}) + (-3 \text{ dB}) + (-3 \text{ dB}) + (-3 \text{ dB}) = -15 \text{ dB}$  change.

When talking about satellite signals, many times we refer to how much power is lost



**Figure 1: SatPC32 footprint AO-51.**

We see that each time you double the power there is a 3 dB increase, so if you double it three times ( $1\text{W} \rightarrow 2\text{W} \rightarrow 4\text{W} \rightarrow 8\text{W}$ ) you have  $3\text{dB} + 3\text{dB} + 3\text{dB}$  or a 9 dB increase. If you start with  $100\text{W}$  and double it 3 times ( $100\text{W} \rightarrow 200\text{W} \rightarrow 400\text{W} \rightarrow 800\text{W}$ ) you will also have a 9 dB increase. Likewise if you halve the power then halve it again, you have a -6 dB change.

For a little more perspective, let's start with a 1 Watt signal and halve it 5 times.

$[1\text{W} \rightarrow 0.5\text{W} \rightarrow 0.25\text{W} \rightarrow 0.125\text{W} \rightarrow$

in getting to the receive antenna. Say the satellite is transmitting  $500 \text{ mW}$  and the signal power measured at the ground-based antenna is  $2 \times 10^{-13}\text{W}$ . We simply substitute these values into the dB equation  $\text{dB} = 10\log(2 \times 10^{-13}/500) = 10 \log (4 \times 10^{-16}) = 10(-15.397) = -154 \text{ dB}$  loss (the path loss). Remembering that each -3 dB change is half the power, a -154 dB loss is quite a bit of power loss, and a very weak signal.

If the reference signal used is  $1 \text{ mW}$  we call this ratio dBm, while a reference value of  $1\text{W}$  is referred to as dBW.

Table 3 has some common dB values that you should be familiar with.

### Path Loss Continued

With the dB review under our belts we can further explore the effects of path loss on the satellite signal. The free space path loss formula is  $L_{\text{dB}} = 92.4 + 20 \log f + 20 \log R$ , where  $f$  is the frequency in GHz and  $R$  is the distance in km and the loss value is expressed in dB. Electromagnetic signals quickly lose energy as they travel through space. Exactly how much energy is lost I think will astound you.

Substituting some standard satellite frequencies and distances into Table 4 we see the incredible effect of distance in decreasing signal strength.

One of the first things I notice is that if a  $1\text{W}$  signal is transmitted on  $145 \text{ MHz}$  and on  $435 \text{ MHz}$  from the same satellite we take a -10 dB hit on the  $435 \text{ MHz}$  signal just because it is at a higher frequency. At  $2.4 \text{ GHz}$  the loss is -24 dB more than a  $145 \text{ MHz}$  signal (remember that each -3 dB is half the signal strength). Now these numbers are for losses in free space. Inside the earth's atmosphere you will get a little more attenuation, but note that even at a distance of  $64 \text{ km}$  ( $38 \text{ mi}$ ) even the signal from your local repeater takes quite a hit.

### Atmosphere Attenuation

When signals from the vacuum of space encounter the earth's atmosphere they are further attenuated. A good ballpark range for atmospheric attenuation is somewhere between -1.0 and -2.7 dB. This will directly add to the path loss. This attenuation affects the lower frequencies (even  $2\text{M}$ ) more than the higher frequencies.

### Satellite Antenna Gain

One way to improve the link margin is for the satellite antenna to have more gain. More power is theoretically an option, but rarely is extra power available on a satellite. A key concept in spacecraft design is tradeoff. To improve antenna gain the most common items involved in the tradeoff are space and mass for an antenna(s) with more gain. Determining these are all part of the satellite design process. The gain of the satellite antenna will reduce the path loss figure by the amount of the antenna gain in dB. Sometimes the antenna gain is given as dBi and other times in dBd. The dBd value is compared to an isotropic radiator (these are theoretical antennas, that radiate equally

*continued on page 20 ....*



## The Orbital Classroom

## #1, March 2006

by Dr. H. Paul Shuch, N6TX, AMSAT Director of Education



## The Orbital Classroom

**H**aving recently retired for the second time (the first retirement, in 2004, was from academia; the second, just recently, from industry), I am very pleased to accept appointment to the post of AMSAT Director of Education. This new column, which will appear from time to time in *The AMSAT Journal*, will serve as a forum for sharing resources, and furthering AMSAT's educational mission.

Since its inception nearly four decades back, AMSAT has taken on an important role: bringing satellite technology into the classroom. Through our various OSCARS, SAREX, ARISS, and participation in the Cubesat program, many of us have exploited the mystique of space to captivate the interest and imagination of our students. But, we have not always done so in a coordinated manner. Coordination is a skill I most hope to bring to my new assignment.

My first priority as Director of Education will be to promote integrated curriculum development at all levels (K through PhD), with emphasis on using satellites in the classroom, to enhance the teaching of science, math, geography, social studies, technology, and the social sciences. To accomplish this, I turn to you, the membership, to lend what significant resources and expertise already exist within our organization. I invite all teachers within AMSAT to share with me their current, past, or planned use of satellites in the classroom, their instructional materials, and their desires in terms of future curricular development. All professional teachers, curriculum developers, and school administrators within AMSAT's ranks are invited to sign up as official AMSAT Educators (signup instructions will appear in the Orbital Classroom section of the AMSAT Web site). You will receive not only a nice certificate, but an opportunity to contribute materially to a coordinated and redoubled AMSAT educational effort.

I respectfully suggest that one key aspect of doing anything in the US educational arena is a need for those efforts to be tied to the federal No Child Left Behind Act, as well as the published educational competencies and graduation standards established by the various States. I hope to work together with

our cadre of AMSAT Educators to evaluate the competencies and standards in force in the individual states, so that our curriculum efforts can tie in to them to the greatest possible extent. Of course, we being AMSAT NA, I rely upon the expertise of our Canadian and Mexican AMSAT Educators to bring me up to date on the educational standards and curriculum requirements throughout the rest of North America.

One area in which AMSAT already has a rich history of educational activities is human spaceflight, most recently through the ARISS Program. I would not presume to modify these existing programs in any way. However, ARISS contacts should not be an end unto themselves. ARISS generates a great deal of enthusiasm, leading up to a contact with the astronauts on the International Space Station. Coordinating closely with Frank Bauer, AMSAT VP Human Spaceflight, I will be seeking ways we can encourage ARISS schools and teachers to take the next step with programs to leverage that enthusiasm into an ongoing interest in math, science and Amateur Radio.

Another key area of attention for your new Director of Education will be Cubesats. There is a definite educational mission in satellite construction, which goes far beyond the production and launch of a payload. We should be seeking to find a way to get

satellite builders talking to satellite users in an educational setting. It is my hope that, by finding specific educational applications of existing and planned small satellites, and by providing proper training to satellite developers, we will get them fired up about supporting the classroom use of their creations.

AMSAT has a proud history of both technical and educational accomplishment. With your help, we can make great strides. I thank AMSAT's senior leadership team for providing me with this opportunity to further serve an organization that has been near and dear to my heart for three and a half decades (which, incidentally, is about as long as I taught). With your help, I'll certainly not be bored in my second retirement! 🍷



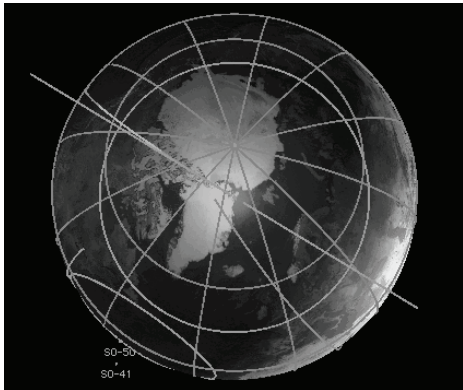
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## 2006 Hamvention® Theme

"Ham Radio IS Public Service" is the theme for Hamvention 2006, reflecting the renewed awareness by the public of the service provided by Amateur Radio operators after the Gulf Coast hurricanes and other disasters. In announcing the theme, Hamvention 2006 General Chairman Jim Nies, WX8F, said that it serves to remind the public and the ham radio community that one of the reasons ham radio exists is to provide communication in emergencies when all else fails. Several forum sessions are expected to deal with topics related to emergency communication, including how Amateur Radio performed after the hurricanes wiped out communications in a wide segment of the south.

In other news, Inside Exhibits Chairman Gary Kopas, KC8CSH, said that sales of inside space are running slightly ahead of last year with about half of the spaces already committed and more orders coming in each day. Several major vendors have also already made prize commitments. Orders for exhibit and flea market spaces and advanced tickets are all available on the Hamvention Web site, [www.hamvention.org](http://www.hamvention.org).

The golf cart shuttles, which were popular last year will be back. The shuttles, which move people around the Hara Complex, can be utilized by anyone if space is available but those with impairments have priority. This year additional shuttles will be used to move purchases out of the flea market since automobile traffic is not permitted while the flea market is open.

Many key vendors have already committed to returning to Hamvention, which the Dayton/Montgomery County Convention & Visitors Bureau estimates produces an economic impact of close to \$4 million for Montgomery County and nearly \$10 million regionally. Hamvention, the world's largest Amateur Radio gathering, brings more than 25,000 people to the greater Dayton area each year. The three-day event includes exhibits, a flea market, forums and education sessions.

For more information about Dayton Hamvention 2006 (scheduled for May 19-21), visit the Web site at [www.hamvention.org](http://www.hamvention.org) or e-mail [media@hamvention.org](mailto:media@hamvention.org).



## Call for Papers - UK Colloquium

This is the first call for speakers for the 21st AMSAT-UK Colloquium, which will be held at Surrey University, Guildford, Surrey, U.K., from Friday 28 July to Sunday 30 July 2005. AMSAT-UK invites speakers about Amateur Radio, space and associated activities for this event. They are also invited to submit papers for the "Proceedings" document, which will be published at the same time, but printed papers are not mandatory. We normally prefer authors to present talks themselves rather than having someone else give them in the authors' absence. We also welcome "unpresented" papers for the Proceedings document.

Offers of talks should be submitted as soon as possible; the final date for full documents to be received is mid-June 2004 so that the "Proceedings" document be available to participants.

Submissions should be sent **\*ONLY\*** to David Johnson, G4DPZ, via the following routes:

Internet e-mail: [g4dpz@amsat.org](mailto:g4dpz@amsat.org)

SnailMail: QTHR from <http://www.qrz.com>

AMSAT-UK also invites anyone with requests for Program Topics to submit them as soon as possible to G4DPZ. Invitations for any papers on specific subjects will be included in the future call. Likewise if anyone knows of a good speaker, please send contact and other information to G4DPZ.

Additionally, AMSAT-UK will be running sessions specifically for beginners to amateur satellite operating on the Friday; volunteers are wanted to speak at these sessions.

73 Jim, G3WGM ☸  
Hon Sec AMSAT- UK

## Volunteer Members of AMSAT Come Through Again! 2005 Volunteer Service Donations up 25% by Gunther Meisse, W8GSM AMSAT Treasurer

Volunteers, again in 2005, came through with a record breaking \$457,477 worth of services to our AMSAT organization. This breaks last year's record by 25%. Services are reported to the AMSAT Volunteer Reporting System hosted on the [amsat.org](http://amsat.org) Web site. Members provided over \$220,000 in services in the Spacecraft Design, Construction and Operations department. Following this category was Member Services which totaled nearly

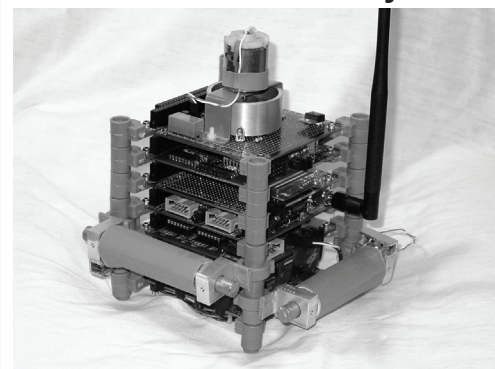


\$107,000. Educational Outreach totaled over \$64,800 and Administration of the AMSAT organization totaled some \$56,700.

These donations of time by members make a real difference in the effectiveness of AMSAT. These same efforts would cost us tens of thousands of additional dollars if we had to pay market prices for these worthwhile services. From doing very technical scientific design work on Eagle and P3E, very detailed administrative work in our Silver Spring, MD office, educational outreach assisting universities develop spacecraft, to the membership services we all use and count on, these members are to be commended for their service-above-self.

If you are one of the many AMSAT volunteers who have not yet joined the AMSAT VRS program, we urge you to go to [amsat.org](http://amsat.org) and click on the "Becoming a Volunteer" link on the left side of the home page. You will get full details on the services that qualify for reporting and be given specific instructions for signing up. Please check it out and join us in telling the world just how hard AMSAT members work assisting in our program of work. ☸

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In a multi-frame panorama of The National Building Museum, Frank Bauer, KA3HDO, briefs on the approaching live ISS contact, while Dave Taylor, W8AAS, (left foreground) controls the crowd.



Showing ways ham radio is Fun!



Transmitting a question to astronaut/cosmonaut aboard the ISS.

Alongside corporations and agencies, we enjoyed sharing and igniting interest in visitors to the table during the “Discover Engineering Family Day” in Washington. The touchable display showed AMSAT satellites, the ISS transceivers, headset, AX.25 controller, clamp-on antennas, and SSTV equipment. The projected “Nova” tracking program plotted ISS for the real-time Q&A QSO.

Photos courtesy of Bill Boston, N3DCI



Preparing to demonstrate ham radio to interested onlookers.



W3PK - Perry Klein explains AMSAT programs.



W4ART - Art Feller displays a Cubesat.



## Space Probe Voyager 1 Successfully Received by Hartmut Paesler, DL1YDD, dl1ydd@amsat.org

**O**n March 31, 2006 an AMSAT-DL/IUZ team received the American space probe Voyager 1 with the 20 meter antenna in Bochum. The distance was 14.7 billion km. This is a new record for AMSAT-DL and IUZ Bochum. The received signal was clearly identified through means of Doppler shift and position in the sky. The receive frequency was exactly measured and compared with the information provided by NASA.

This distance equals approximately 98 times the distance between Earth and Sun. Voyager 1 is the most distant object ever built by mankind. This again proves the excellent performance of the Bochum antenna. Most probably this is the first time Voyager 1 has been received by radio amateurs.

Voyager 1 was launched on 5 September 1977 by NASA. It transmitted the first close-up pictures of Jupiter and Saturn. In 2004 Voyager 1 passed the Termination Shock Region, where the solar wind mixes with interstellar gas. Voyager 1 today is still active, measuring the interstellar magnetic field.

The following radio amateurs were involved:

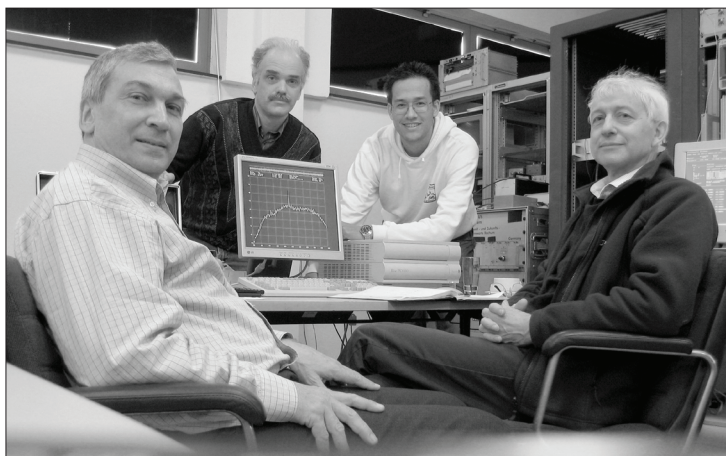
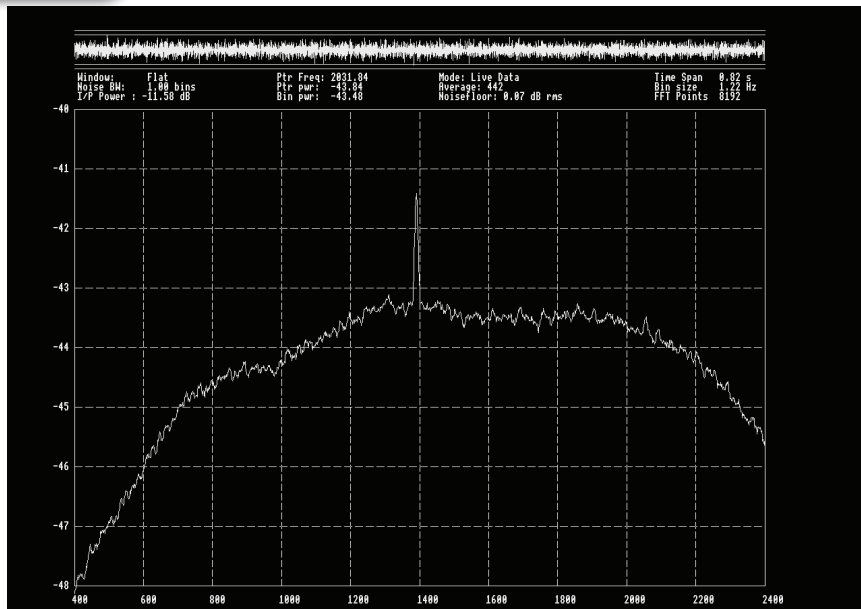
- Freddy de Guchteneire, ON6UG
- James Miller, G3RUH
- Hartmut Paesler, DL1YDD
- Achim Vollhardt, DH2VA/HB9DUN

Special thanks to Thilo Elsner, DJ5YM, of the IUZ Bochum, Roger Ludwig of Jet Propulsion Laboratory (JPL), Pasadena, CA, USA and DSN.

For more information please visit:

<http://voyager.jpl.nasa.gov>

<http://www.amsat-dl.org/cms> under "News"



*The group of amateurs that lead the effort to receive Voyager 1 signals shown in this photo are (from left to right): Freddy de Guchteneire, ON6UG; Hartmut Paesler, DL1YDD; Achim Vollhardt, DH2VA/HB9DUN; and James Miller, G3RUH.*



*The antenna is 20 m in diameter with approximately 140 tons of moving mass. It has a pointing accuracy on the order of 0.01°, a beamwidth at 8.4 GHz of 0.12°, one quarter of the Moon's apparent diameter. The subreflector is 3 m across. The center hole is approximately 3 m in diameter. All the LNAs, transverters and amplifiers are mounted there and you can easily stand and work. Please refer to the article by James Miller, G3RUH, in the Nov/Dec 2005 issue of The AMSAT Journal.*

*Hartmut also reports that recently the team transmitted a 10.5 GHz signal with high power to the moon to give EME operators the opportunity to measure polarization changes. He says "Our signal reflected from the moon equals a 50 W transmitter on the moon. We have reports of good reception with 60 cm dishes."*



## AMSAT Eagle Update

James A. Sanford, PE, WB4GCS  
Eagle Project Manager

*Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012...*

The efforts of your Eagle team are accelerating. The most exciting news is that John Stephenson, KD6OZH, has produced a design for the 70cm receiver to be flown in Eagle. By "design" I mean schematics and a report describing functions, constraints and reasons for design choices. I have submitted this design to a peer review group, which will go over it rigorously. By the time that you read this, I hope that the formal peer review process will be complete and John will either be making refinements or working on the prototype. Once a design is approved, we'll make it available on the AMSAT Web site and I encourage you to study it. Those of us who enjoy the weak signal work and live for sub -1db Noise Figures will find some surprises – all very carefully analyzed and justified.

The CAN-Do team is working through development of a file/block transfer protocol for payload modules that will use byte-pipe mode. The initial customer for this is the camera team, and they're heavily involved in the process.

Alan Bloom, N1AL, presents an interesting article in this issue, "Stabilizing Eagle," which I encourage you to read carefully. Although the Eagle Functional Requirements specify spin stabilization, as we pursue rigorous science in our design discussions, we've also discussed the possibility of 3-axis stabilization, which was tested in AO-40. Alan discusses the merits and disadvantages of both spin and 3-axis stabilization and explains the impact of each on the sensor suite. He then makes a recommendation, which I'll let you read in his words. The team is continuing to examine all options.

Sensors are one of those things that are "black magic" to many of us. Alan's article provides a quick summary of sensors being considered and references a paper he presented at the 2004 AMSAT Space Symposium in Arlington. I went back and re-read that paper, and found it very informative. If you don't already have it, call Martha and order the 2004 Proceedings. There is a wealth of great information there.

Speaking of Proceedings, while I was working a local hamfest last weekend, I purchased and started reading the Proceedings of the 2005 Space Symposium. These are the

papers which would have been presented had Katrina not disrupted so many things and people. I highly recommend that you purchase and study those Proceedings as well. If you want to know the detailed thinking and analysis that is going in to the Software Defined Transponders in Eagle and some of the work on IHU-3, then this book is **MUST READING**. If you don't already have it, call Martha and get it.

On a personal note, my AMSAT Symposium Proceedings sit right next to my Microwave Update Proceedings. They are dog-eared, tabbed, highlighted and underlined. As I design my 6m through 10 Ghz microwave station here in SW Pennsylvania, these books are where I turn for state of the art thinking.

Dick Jansson, WD4FAB, reports on development of the standard modules for our payloads. The Eagle standard modules are 125x180mm (4.92x7.09 inches), 200x180mm and 275x180mm. As components get smaller and circuits become more highly integrated, the need for the larger modules is diminishing. In late 2005 the Eagle team decided that it would be useful to fabricate several of the modules that have been designed, to validate both the design and our construction processes. The mechanical team; Bob Davis, KF4KSS, Fred Parker, KF0AK, and Dick; worked to prove the design of the module housings for the Eagle electronics. Machining and fabrication fixtures, jigs, Numerically Controlled Machine (NCM or NCS) codes and processes were developed, executed and evaluated. The proving effort consisted of machining trial quantities of module parts. These, in turn, were used to do careful fit-checks of those parts as an assembly. Along the way a few, but only a very few, design changes and adjustments had to be made to the parts and drawings. Other than these small changes, the machining and assembly steps all went very much as had been planned from the concept of the module drawings. The photos in the January/February 2006 issue of The AMSAT Journal show the results. Evaluations continue, and we will show the Engineering Models at Dayton.

Work on the Software Defined Transponders (SDX) continues. Again, read the papers in

the 2005 Symposium Proceedings to see where this is heading. We will demonstrate a prototype of the SDX at Dayton – be there, and bring your satellite rig!

I noticed that the Eagle thermometer reading on the AMSAT Web site has nearly doubled since I last wrote this column. Thank you all for your encouragement and support.

As always, comments and questions to: [wb4gcs@amsat.org](mailto:wb4gcs@amsat.org)

73,  
Jim



Hello All,

A number of people on the reflector have bought kits of my pre-amplifier design published in *The AMSAT Journal* in Aug 2005. The design was intended to give good performance at 435 and 1296 MHz. The article showed a graph giving details of the performance to 1500MHz. Thanks to some further testing by a UK constructor who is an RF professional, I now have some figures for gain and noise figure beyond 1500MHz.

| Freq | NF   | Gain |
|------|------|------|
| 432  | 0.6  | 21   |
| 1296 | 0.48 | 20   |
| 1500 | 0.49 | 18   |
| 2000 | 0.64 | 14   |
| 2320 | 0.65 | 14   |
| 2500 | 0.66 | 12   |
| 2900 | 0.8  | 12.5 |
| 3000 | 0.78 | 12   |
| 3400 | 1.0  | 11   |

As you can see, the performance is still quite useful at 13cms but the preamp is beginning to run out of gain 3400. On this particular example the coils were wound with an internal diameter of 2.5mm and the NF at 432 is a little too high. 2.7mm coils would improve the performance by moving the cut-off down to 400MHz. The best noise figure was measured at 850MHz where it was a fraction below 0.4dB.

It was also observed that cooling with a Peltier device to 0 degrees Centigrade improved the NF performance by a further 0.05dB.

Regards,

David, G0MRF

<http://www.g0mrf.freemove.co.uk/432LNA.htm>





## SuitSat Wrap Up

by Frank Bauer, KA3HDO, [ka3hdo@amsat.org](mailto:ka3hdo@amsat.org)  
AMSAT-VP for Human Spaceflight Programs  
ARISS International Chairman

SuitSat-1/Radioskaf/AO-54, the mission that has captured the imagination of people and students around the world, is now a confirmed silent key. The outreach, press requests and visibility of SuitSat were absolutely amazing and appear to be unprecedented for a ham radio event. While the press requests are just now starting to wane, we expect that you will continue to see SuitSat status reports and pictures in magazines, Web sites and other literature over the next few months. One metric that shows the interest - we had over 9 MILLION hits at the [www.suitsat.org](http://www.suitsat.org) Web site. Quite impressive indeed!!

Based on the reports we have received, the last confirmed reception of the SuitSat voice audio was on Saturday, February 18 at 3:32 UTC by Bob King's station, VE6BLD, in Canada. The last confirmed telemetry was received by Richard Crow's station, N2SPI, in the USA. Richard copied the SuitSat-1 voltage dropping precipitously to a low of 18.3 volts before vehicle stopped transmitting. SuitSat-1 operated for over two weeks, much longer than the 4-9 day initial predictions.

Despite its much lower than expected signal strength, SuitSat-1 was heard by ham radio operators and school students around the world. SuitSat's low signal strength required antennas with some gain. Many, including me, heard SuitSat with a 3-element Arrow antenna attached to a handheld radio. Another challenge to signal reception was the very deep fades due to the Suit rotation. One great positive that came from these issues is that it challenged the ham radio community, worldwide, to improve their station receive capabilities so that they could pull every bit of signal from SuitSat.

### "Virtual Reception"

"Virtual reception" of the student messages, SSTV image and telemetry was made possible through SuitSat Web sites and blogs that stored MP3 files from key ham radio stations around the world. The SuitSat team thanks these system administrators as well as our international ham radio "detectives" that worked around the clock to receive the SuitSat signals and compile the telemetry.

Some of the key Web sites that were instrumental in this mission included the [www.suitsat.org](http://www.suitsat.org) Web site sponsored by

Steve Dimse, K4HG, <http://www.aj3u.com/blog/> sponsored by A.J. Farmer, AJ3U, and <http://pd0rkc.ontwikkel.nl/> sponsored by Cor. In addition, bulletins sent by Miles, WF1F, the AMSAT news/Web page team - Emily, N1DID, JoAnne, WB9JEJ and many others around the world kept all of us informed while SuitSat operations unfolded. As a result of these efforts and the efforts of our ham radio detectives, teams have identified the "secret words", the messages from students and Mr. Alexandrov, the SSTV image and the telemetry.

### SuitSat Myths Debunked

There were reports that the Suit was non-operational and that the battery was frozen shortly after deployment. This NEVER occurred. As the telemetry has shown, temperatures within the Suit were a somewhat comfortable 12-16C during the entire mission. So the "frozen battery" myth is just that--a myth.

So is the early demise and resurrection of the SuitSat. It was alive and operated flawlessly, except the signal strength issue, from the time the crew flipped the switches until the battery power was used up.

Another potential myth is the statement that the radio output is 1-10 mW. More precisely, the SIGNAL STRENGTH was much lower than expected. It is entirely possible that the radio output could have been at 500 mW and the feedline, connector or the antenna caused the problem.

### SuitSat Signal Strength Issue Investigation

The SuitSat team is just starting to look at the potential causes of the vehicle low signal strength. As described above, the cause was either an issue with the antenna, feedline, connectors, power amplifier of the radio or some combination of the above. As we conduct this investigation and start to learn information on the potential cause, we will provide public releases on this.

### SuitSat Educational Outreach

As was mentioned, many schools around the world have participated in SuitSat operations. One example of this is the R. Tait McKenzie Public School in Almonte, Ontario. Neil Carleton, VE3NCE, sent us this message: "Thank you to the SuitSat team

for the opportunity to have students involved in such an exciting space project. It's been a week of adventure, and I'm happy to report on the involvement of my class as part of our grade 6 science studies of space."

The ARISS team also plans to harvest the substantial SuitSat downlinks obtained by the ham radio community to develop lesson plans for schools. One great idea is to use the audio with the spin fades as well as the EVA release video to let students determine whether the spin rate slows down, speeds up or remains the same during the mission - a simple physics experiment using ham radio! We have many other ideas for lesson plans too.

### SuitSat Orbit Life

Prior to the SuitSat deployment, we received an orbit analysis that predicted a 70-120 day orbital life for SuitSat. This would put SuitSat deorbit around mid-April to early June. The orbit life, of course, is dependent on the atmospheric drag that the satellite experiences. More details will be provided as de-orbit approaches.

### SuitSat Additional Object

An extra object has been observed to have detached from SuitSat and become its own satellite. This object is most likely one of the SuitSat gloves or the Student CD which was attached on the outside of the Suit.

### SuitSat Visual Passes

There has been at least one visual of SuitSat. You can see that on A.J. Farmer's blog. Let us know if you see SuitSat. I expect you will need binoculars to see it.

### SuitSat Accomplishment Summary

While the transmission part of the SuitSat experiment was not stellar, SuitSat-1 has been tremendously successful in several areas. Some of these successes include:

- We captured the imagination of students and the general public worldwide through this unique experiment
- The media attention to the SuitSat project was tremendous
- We have had well over 9 million Internet hits on [www.suitsat.org](http://www.suitsat.org) Web site
- Our student's creative artwork, signatures and voices have been carried in space and are on-board the spacesuit - the



students are now space travelers in the Suit as it circles the Earth. This was a collaboration with the NASA Explorer Schools.

- The ARISS international team was able to fabricate, test and deliver a safe ham radio system to the ISS team 3 weeks after the international space agencies agreed to allow SuitSat to happen. This was a tremendous feat in of itself.

and most importantly,

- We successfully deployed an Amateur Radio satellite in a spacesuit from the ISS, demonstrating to the space agencies that this can be safely done.

The above engineering accomplishment will open new opportunities for small, low cost satellites in the future.

### Special Certificate/Diploma

If you heard SuitSat don't forget the special SuitSat certificate/diploma. Information on obtaining this certificate/diploma can be found on the AMSAT Web site: [www.amsat.org](http://www.amsat.org)

### The Future

The AMSAT/ARISS team has been talking about a SuitSat-2. Correcting the signal strength issue would be a top priority for this flight. So would be a longer-term power generation device, like solar arrays. As our thoughts mature on this, we will keep you informed of our plans.

SuitSat-1/Radioskaf/AO-54 represented a space pioneering effort. While we did not have total success, we captured the imagination of students and the general public worldwide. And we have learned a lot from this activity. This will help us and others grow from this experience.

On behalf of the AMSAT, ARISS and SuitSat teams, I thank you all for your help, encouragement and advice. 🌐

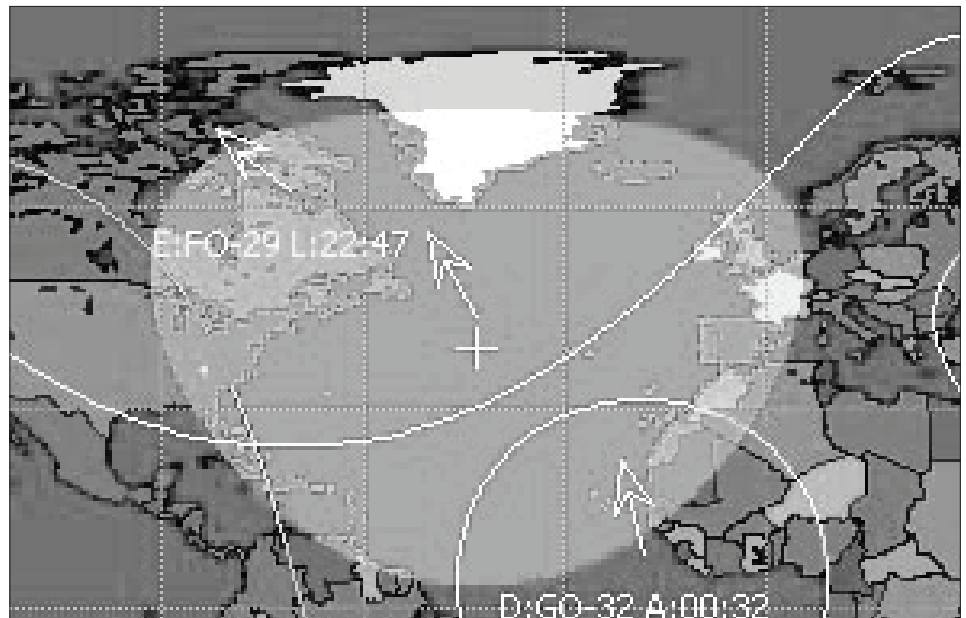
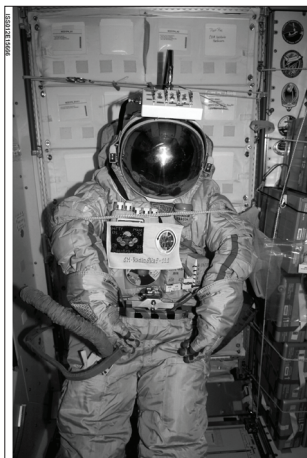


Figure 2: SatPC32 footprint of AO-7.

well in all directions); dBd compares the gain in the antenna to a dipole. The power rating difference between dBd and dBi is approximately 2.2; that is 0dBd = 2.2 dBi.

### Receiver Signal Value

Many of the 70 cm receivers need a signal of at least -120 dBm for 12dB SINAD. So the goal is to present a higher-level signal to the receiver so you aren't right at the noise level. Looking at Table 4 you can see you are starting out with quite a deficit and this needs to be made up before the signal gets to the receiver.

### Link Budget

All of this is working toward your understanding all of the values included in computing a link budget for each satellite for your station. The link budget will tell you whether you can receive the satellite signal and how well. Terry Osborne, ZL2BAC, has provided us with a useful tool in his Excel spreadsheet to calculate an AO-51 Link Budget.

[http://www.amsat.org/amsat-new/echo/Echo\\_Linkbudget.php](http://www.amsat.org/amsat-new/echo/Echo_Linkbudget.php)

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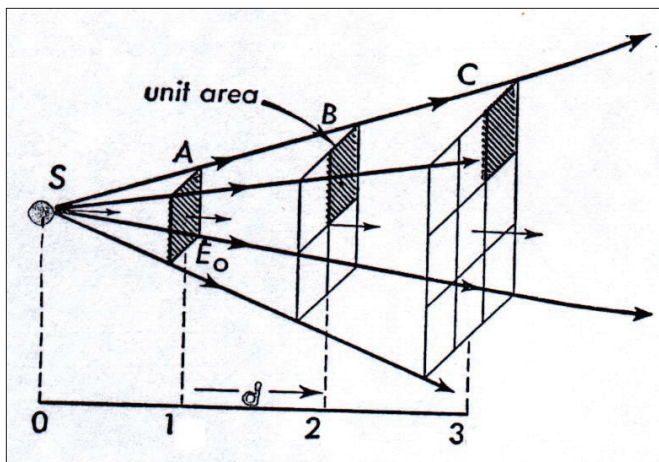


Figure 3: Wave dispersal and the Inverse Square Law, from *Physics, An Exact Science*.

Those AO-40 operators among you I am sure remember the extremely useful AO-40 Link Margin spreadsheet (AO-40 Ground Station Evaluation Tool) by Gene Marcus, W3PM. These tools will again become very

| dB    | P1 / P0 | Sample Values          |
|-------|---------|------------------------|
| -30   | 10-3    | 1000W start, 1W end    |
| -20   | 10-2    | 20W start 0.2W end     |
| -10   | 0.10    | 4.6mW start 0.46mW end |
| -6.02 | 0.25    | 4W start 1W end        |
| -3    | 0.501   | 12mW start 6mW end     |
| 0     | 1.0     | 62uW start 62uW end    |
| 3.01  | 2.0     | 0.3W start 0.6W end    |
| 6     | 3.981   | 1fW start 4fW end      |
| 10    | 10      | 10W start 100W end     |
| 20    | 100     | 5mW start 500mW end    |
| 30    | 1000    | 3mW start 3W end       |

Table 3: Common dB reference values.

important as P3E and Eagle soon become satellites and operational. A day we are all looking forward to.

### Next Time

We have gotten the signal from the satellite and through the atmosphere. Next up is deciding which antenna to use to collect this very weak signal. I will go over many of the popular satellite receive antennas, preamps and coax in Satellites Signals and Reception, Part II.

### References:

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*RF Power Values Explained*, Cisco Systems, May 2004 [http://www.cisco.com/en/US/tech/tk722/tk809/technologies\\_tech\\_note09186a00800e90fe.shtml](http://www.cisco.com/en/US/tech/tk722/tk809/technologies_tech_note09186a00800e90fe.shtml)

White, Harvey, *Physics, An Exact Science*, D. Van Nostrand Co, Inc. 1959

Tony Monteiro, AA2TX, for suggestions, improvements and fact checking. ☺

| Distance in km | 2.4 GHz | 1.2 GHz | 435 MHz | 145 MHz | 5.84 GHz | 25 GHz |
|----------------|---------|---------|---------|---------|----------|--------|
| 64             | -136    | -131    | -121    | -112    | -143     | -156   |
| 300            | -149    | -144    | -134    | -125    | -157     | -169   |
| 800            | -158    | -153    | -143    | -133    | -165     | -178   |
| 1000           | -160    | -154    | -145    | -135    | -167     | -180   |
| 5000           | -174    | -168    | -159    | -149    | -181     | -194   |
| 10000          | -180    | -174    | -165    | -156    | -187     | -200   |
| 20000          | -186    | -180    | -171    | -161    | -193     | -206   |
| 30000          | -190    | -184    | -174    | -165    | -197     | -209   |
| 40000          | -192    | -186    | -177    | -168    | -199     | -212   |
| 50000          | -194    | -188    | -179    | -170    | -201     | -214   |
| 60000          | -195    | -190    | -180    | -171    | -203     | -215   |

Table 4: Path Loss in dB.





## Stabilizing Eagle

Alan Bloom, N1AL, n1al@cds1.net

Up until now, most amateur satellites have been spin-stabilized. A spinning satellite acts like a top, or a gyroscope. The angular momentum maintains the spin axis in a constant direction so that small perturbations do not cause a change in spacecraft attitude.

By contrast, the AO-40 satellite was intended to be three-axis stable. A set of three internal momentum wheels were included to maintain a stable attitude. By changing the

high-gain antennas with quite narrow beam widths. So narrow in fact that the Earth is too far outside the beam pattern to maintain communications over most of the orbit.

There are two possible solutions. One is to use spin stabilization with rotating antennas to "de-spin" the antenna pattern and maintain the Earth in the center of the pattern. This does not necessarily require mechanically movable antennas. Multi-element antennas (such as an array of patch antennas) can be

to design non-rotating antennas for higher gain, which would simplify ground station requirements. In addition, there is some risk that "de-spinning" the rotatable antennas won't work for some reason. If that happened, the antennas would have to be left in the "neutral" position (aligned with the spin axis) so they only work when the satellite is near apogee.

The second advantage is that we may be able to get away with fewer solar panels. It should be possible to orient the satellite to keep the same side always pointing in the direction of the sun. Only two or three panels would be required, rather than the six that are currently planned.

### The Bad News

There are a number of disadvantages to three-axis stabilization. First, note that even if that mode is chosen for Eagle, we still have to support spin-stabilized mode since it will be used early in the flight during motor firings. Any features required for spin-stable mode must be present, so we do not gain any advantage in cost, complexity or reliability by using three-axis stabilization as the operational mode. The exception to that is the fewer solar panels mentioned above. So long as the transmitters are not operating continuously during navigation we should be able to get by with less available power.

Three-axis stabilization greatly increases complexity. The obvious example is the momentum wheels. Mechanical devices are inherently less reliable than non-moving assemblies. If they fail the satellite would have to go to spin mode with less available power from the solar panels. The momentum wheels also add mass to the satellite, which means a bigger motor is required. The three-axis control algorithms are complicated and have never been tested in space on an amateur satellite. Momentum wheels require power from the solar panels to operate. Finally, whenever a wheel's spin rate is reduced, the excess energy must be dissipated somewhere, which affects the thermal design.

Thermal design in general becomes more difficult. The side of the satellite pointing toward the sun typically sees temperatures above the boiling point of water. The side pointing toward space sees a few Kelvins above absolute zero, -490° F. If the satellite is not spinning we'll need some method to

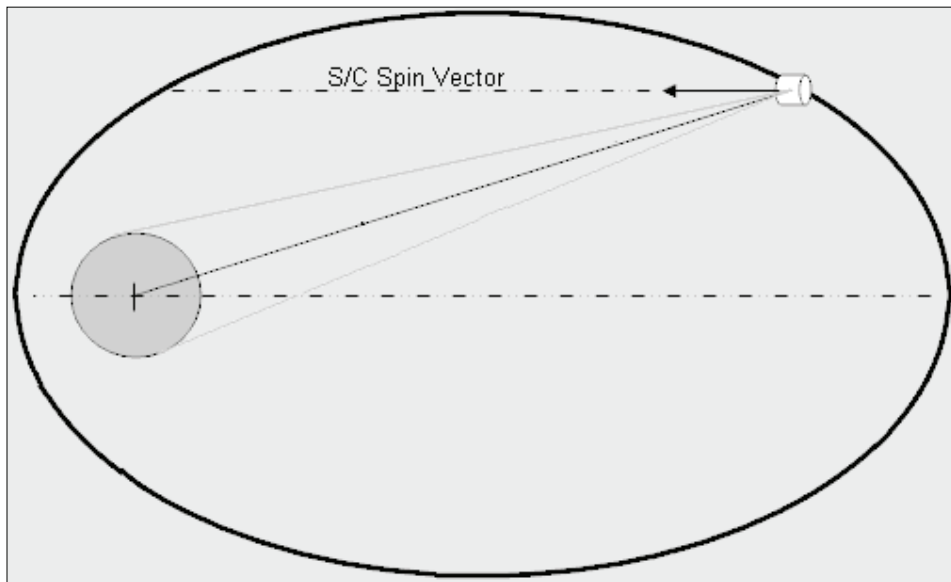


Figure 1

rotation rate of one or more of the wheels the orientation of the satellite in space could be changed as desired. Unfortunately we were never able to establish 3-axis stabilization before she went silent.

The guiding principle for Eagle is KISS (Keep It Simple). In that spirit, the original plan was to use spin stabilization, with the spin axis aligned with the orbital major axis. The high-gain antennas point in the direction of the spin axis for maximum gain at apogee. As the spacecraft moves away from apogee, gain decreases because the Earth is no longer at the center of the antenna radiation pattern (see Figure 1). However, the distance to the Earth also decreases so it was hoped that the antenna pattern could be shaped to maintain a constant path loss over a large portion of the orbit.

Since then, systems designers have been busy with their (electronic) slide rules. They have calculated that the path loss on S and C bands at the 36,000-km apogee requires

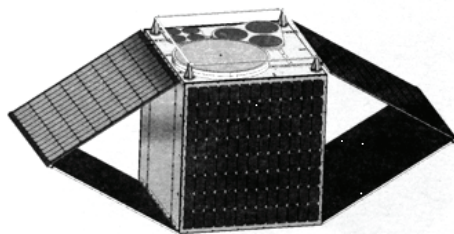
rotated electronically by varying the phase of the RF signal to each antenna.

The other solution is three-axis stabilization. The spacecraft is periodically turned during the orbit to keep the antennas pointing at the earth.

### The Good News

This paper will argue that spin stabilization is the best method for Eagle. But in the interest of dispassionate analysis, let's first look at the arguments in favor of three-axis stabilization. The method has two main advantages.

The first, obviously, is that no rotating antennas are required. It may be possible



transport heat from the hot side to the cold side to equalize the temperature. AO-40 planned to use heat pipes for the purpose.

To keep the antennas pointed at the earth requires frequent attitude adjustments. It is not reasonable to have a control operator on duty 24 hours a day making constant attitude corrections, so some (so far untested) automatic control method is required.

### Sensor Requirements

Whatever stabilization method is employed, we need a method to determine satellite attitude with respect to the sun and earth. That is the purpose of the sun and earth sensors. Details of their operation were covered in an earlier article.[1]

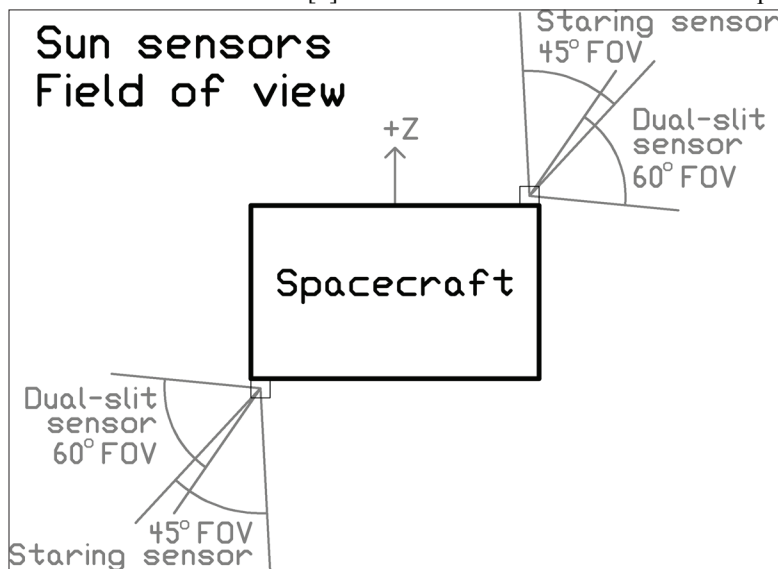


Figure 2

There are two types of sun sensors. The dual-slit sensors depend on satellite rotation to determine sun elevation and azimuth with respect to the spin (Z) axis. The staring-mode sun sensors give the two-dimensional coordinates of the sun's position even when the sun is motionless with respect to the satellite. As shown in Figure 2, two sensors of each type give omni-directional coverage as the spacecraft rotates about the Z axis. The dual-slit sensors don't work if the satellite doesn't spin. Omni-directional coverage would require approximately 24 to 26 staring sensors with 45° FOV. The sensor array would cover much of the available surface of the satellite, leaving little room for antennas.

The Earth sensors are even more of a problem. For spin mode we can use the two Servo Corp. infrared horizon-crossing indicators (HCI) that were purchased by AMSAT through the generous contributions

of the members. These sensors put out a step pulse whenever their narrow field of view moves between the cold of space and the relatively hot Earth. Knowing the horizon-crossing times as the satellite spins along with the data from the sun sensors allows the satellite attitude (orientation in space) to be calculated.

Each of the two Earth sensors sweeps out a cone as the satellite rotates. (See Figure 3.) The "magic" angle for these is 60 degrees from the Z axis, which allows the spacecraft to see the Earth continuously over almost half of the orbit closest to perigee.

Again, the horizon-crossing sensors don't work if the satellite is not spinning. Apparently

there do exist "staring mode" infrared sensors that use arrays of IR detectors. The units we are aware of are expensive and have poor resolution. And, just as with the sun sensors, we would need a lot of them to cover all

directions.

So we would probably not do that. Instead, in addition to the spin-mode sun and earth sensors, we would include three orthogonal on-board gyros, perhaps the ring-laser types that are starting to be used in automotive suspension systems. The controller temporarily spins the satellite so that readings can be taken as described above for spin mode. The readings are used to calibrate the gyros which can then be read whenever needed to determine spacecraft attitude while in three-axis stable mode. The maximum time between calibrations is determined by the drift rate of the gyros, which is unknown at this time. But since calibration is done near perigee, when the omni-directional antennas are used, communications should not be disrupted.

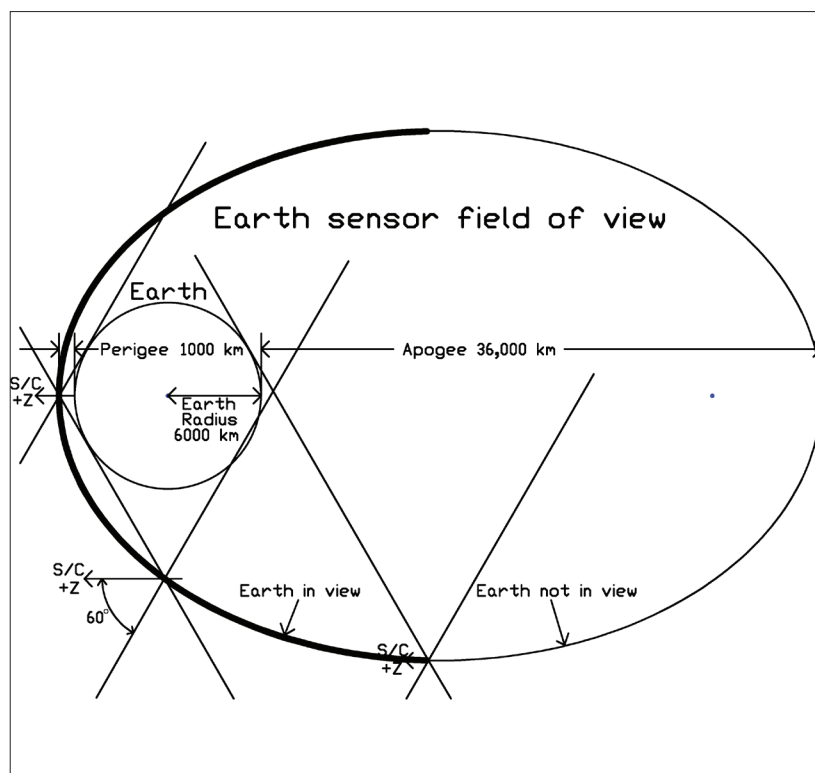
### Conclusion

No doubt three-axis stabilization can be made to work. However it would greatly increase satellite complexity, which adversely affects design time, reliability and launch opportunities (due to the additional weight). My opinion is that we should "keep it simple" and stick with spin stabilization.

### References:

- [1] Alan Bloom, N1AL, "Making Sense of Sensors." Proceedings of the AMSAT-NA 22nd Space Symposium and AMSAT Annual Meeting (2004), pp 59-66. 🌐

Figure 3



## Field Ops Update Gould Smith, WA4SXM Director, Field Operations

It is spring again and that means local hamfests and the Dayton Hamvention®. Many of the volunteer Area Coordinators will be manning tables for AMSAT at these hamfests. If you know a hamfest that should have an AMSAT presence, please send me an e-mail at [wa4sxm@amsat.org](mailto:wa4sxm@amsat.org) and we will try to get someone to represent the organization. Check the Event Calendar on the AMSAT Web site to see when AMSAT will have a representative in your area. This is an excellent opportunity to talk amateur satellites and get up to date news and information.

### Current Area Coordinators

It is very important that all Area Coordinators keep their information in the Area Coordinator database up to date. Most people are changing e-mail addresses every few years. Don't forget to include the AC database when you change providers. This is important to prevent you from not receiving e-mails from prospective satellite operators requesting help or information via e-mails sent using the address stored on the AC list on the AMSAT Web site. It is now quite easy to update your information by using the FOSS (Field Ops Support System) area on the AMSAT Web site. If anyone has login problems, please send me an e-mail. FOSS also has current presentations and help documents for managing a hamfest table and doing satellite demonstrations.

### New Area Coordinators

If you ready to give back to AMSAT, you can start by applying to become a field representative for AMSAT. Or if you know someone that you would be a good representative, you can nominate them, just send me an email telling me why they would be a good representative. Area Coordinators 'Elmer' prospective satellite operators, give talks to local clubs, do satellite operational demonstrations and man tables for AMSAT at local, state and national hamfests.

### Dayton Hamvention 2006

The Dayton Hamvention 2006 will be held on Friday, 19 May through Sunday, 21 May 2006. Hamvention will take place at the Hara Arena Complex on the north side of Dayton. Further information on Hamvention 2006, including advance ticket sales and special discounts for airlines, rental cars and motel accommodations, can be found at [www.hamvention.org](http://www.hamvention.org).

[hamvention.org](http://www.hamvention.org).

AMSAT has a block of rooms reserved at the Hampton Inn in Beavercreek. Please contact Martha ([martha@amsat.org](mailto:martha@amsat.org)) at the AMSAT office for room price and availability for Hamvention. The phone number for the AMSAT office is 301-589-6062. Priority for rooms will be given to those who volunteer to work in the AMSAT booth for multiple 2-hour shifts during Hamvention.

### New Items at Dayton

New members and renewing members at Dayton will receive an AMSAT tote bag with an AMSAT Frequency Guide and an introductory satellite presentation by Emily Clarke, N1DID.

Updated "Getting Started With Amateur Satellites" publication.

New Digital Satellite CD with WiSP, sample digital satellite files from 400 bps through 38k4 bps, Recorder/Playback programs by Douglas Quagliana, KA2UPW, and TImECHO by Mike Kingery, KE4AZN.

In an additional booth space we will have on display a working SDX (Software Defined Transponder) like the one to be used on our Eagle satellite. There will be other Eagle modules on display and Eagle project members will be available to answer questions.

Live satellite operational demonstrations will be conducted Friday, Saturday and Sunday, outside the area, but close to the AMSAT booth. The initial UTC times for the demonstrations are times are shown in Table 1. Parameters: WinAos, QTH: -86.0/39.0, T#: 10365, Sat.: 4 [Standard]. These times are subject to change; check the AMSAT booth for the current list.

### Planned AMSAT Activities at Dayton Thursday, 18 May 2006

Thursday morning there will be a group that sets up the AMSAT booth at Hamvention. If you are interested in helping please contact me at [wa4sxm@amsat.org](mailto:wa4sxm@amsat.org).

Thursday evening the Sixth Annual AMSAT "Pizza n' Suds" party will be held again at Marion's Piazza at 1320 North Fairfield Rd. The party will begin at 6:30 PM and go until the last pizza is gone! Contact Nancy Makley at [kc8gyw@amsat.org](mailto:kc8gyw@amsat.org) for reservations. Bring some friends and have a great time the night before Hamvention. This is an excellent opportunity to talk in a relaxed atmosphere with fellow amateur satellite enthusiasts as well as Eagle team members, AMSAT BoD members and officers.

### Friday, 19 May 2006

Hamvention begins at 8:00 AM for the flea market. Doors open at 9:00 AM for the inside exhibits and Friday technical sessions and

| Day        | Object | AOS (U) | LOS (U) | Period | Max EI | AZ        |
|------------|--------|---------|---------|--------|--------|-----------|
| 19.05.2006 | SO-50  | 13:38   | 13:52   | 14     | 83     | 327 - 152 |
| 19.05.2006 | AO-51  | 14:54   | 15:09   | 15     | 68     | 016 - 188 |
| 19.05.2006 | VO-52  | 15:15   | 15:26   | 11     | 13     | 037 - 152 |
| 19.05.2006 | AO-51  | 16:33   | 16:45   | 12     | 15     | 353 - 241 |
| 19.05.2006 | VO-52  | 16:51   | 17:03   | 12     | 48     | 004 - 207 |
| 20.05.2006 | FO-29  | 12:49   | 13:06   | 17     | 47     | 004 - 214 |
| 20.05.2006 | SO-50  | 14:08   | 14:21   | 13     | 28     | 316 - 174 |
| 20.05.2006 | AO-51  | 14:15   | 14:29   | 14     | 29     | 027 - 168 |
| 20.05.2006 | VO-52  | 15:34   | 15:45   | 11     | 21     | 031 - 162 |
| 20.05.2006 | AO-51  | 15:54   | 16:08   | 14     | 33     | 360 - 218 |
| 20.05.2006 | VO-52  | 17:10   | 17:22   | 12     | 29     | 359 - 217 |
| 21.05.2006 | SO-50  | 12:57   | 13:10   | 13     | 77     | 329 - 147 |
| 21.05.2006 | FO-29  | 13:39   | 13:55   | 16     | 21     | 357 - 237 |
| 21.05.2006 | AO-51  | 15:14   | 15:29   | 15     | 73     | 011 - 198 |
| 21.05.2006 | VO-52  | 15:53   | 16:05   | 12     | 33     | 024 - 175 |

Table 1  
Preliminary satellite demonstration times at Dayton.





closes at 6:00 PM. Maps for the AMSAT Banquet and late reservations (if available) can be made until 2:00 PM at the AMSAT Booth. Come by the booth and find out about the Eagle satellite, get the new publications, shirts and software. We will have a working SDX (Software Defined Radio) system at the booth. There are generally AMSAT officers and board members around if you would like to talk with them. In addition Drew, KO4MA, and team will be conducting satellite demonstrations out in the parking lot Friday, Saturday and Sunday. Check the booth for times.

The AMSAT Banquet will be held Friday evening starting with a happy hour from 6:00 PM until 7:30 PM. Again this year, the buffet banquet will be held at the Amber Rose Restaurant at 1400 Valley St. in old north Dayton. Happy hour will have a cash bar and appetizers starting at 6:30 PM. As with past years the meal will be a buffet. Dinner will be served at 7:00 PM. Price for the dinner is \$27.50 per person and includes appetizers, salad, meal and desert, tax and gratuity. Coffee, tea and iced tea are included. Lou McFadin, W5DID, will be the banquet speaker bringing us up to date on SuitSat-1 and -2.

Reservations are required and the banquet is strictly limited to 90 people maximum. Please contact Nancy Makley, kc8gyw@amsat.org for reservations. Presidents Club Gold members should tell Nancy if you are attending the banquet. Please pay at the door as you enter the second

floor banquet room. Cash, AMEX, Discover, Dinners Club, Visa or Master Card may be used to for payment.

### **Saturday and Sunday, 19-20 May 2006**

Hamvention is open inside from 08:00 AM to 05:00 PM on Saturday. The Sunday hours are from 08:00 AM to 01:00 PM. We will have a working Eagle SDX unit on display at the booth and conducting satellite operational demonstrations. There are generally AMSAT officers and board members at the booth if you would like to talk with them.

### **AMSAT Forum**

This year we have an expanded forum schedule as well as a larger room. The AMSAT Forum will start on Saturday morning at 8:15 AM and end at 10:45 AM. The forum will be in rooms 1 & 4 in the Hara Arena Complex. This year the room will accommodate 500 plus people. The speakers and topics are:

- Moderator: Barry Baines, WD4ASW, VP-Marketing & User Services, AMSAT-NA
- Rick Hambly, W2GPS, President, AMSAT-NA "Phase 3-E Satellite – Design and Development Status"
- Jim Sanford, WB4GCS, Eagle Project Manager: "Eagle Project Overview and Status Report"
- Eagle Project Development Team: "Technology Update: Software Defined Transponder, Internal Housekeeping

Unit, Energy Storage Experiments and Structure Analysis"

- Gould Smith, WA4SXM, Director-Field Operations, AMSAT-NA: "Introduction to AO-51 Operation with a Command Station Update"
- Frank Bauer, KA3HDO, VP-Human Space Flight, AMSAT-NA: "ARISS & SuitSat: Current Status & Future Opportunities"

### **AMSAT Education Forum, Saturday 11:30-12:30**

In addition to the main forum, AMSAT's new Director of Education, Dr. H. Paul Shuch, N6TX, n6tx@amsat.org will coordinate a separate forum for educators. AMSAT also has a mission to efficiently exploit its satellites as educational tools. Beyond the excitement of a classroom contact through a satellite or with an astronaut aboard a space station, satellites provide an orbital classroom for instructional enrichment, in fields as diverse as mathematics, geography, social sciences, physical sciences and technology. In this Forum, professional educators and educational administrators will be invited to share their experiences with satellites in the classroom. AMSAT seeks thereby to recruit a cadre of participating AMSAT Educators, who will develop the curriculum and instructional tools needed to enhance the use of satellites in 21st Century education, at all levels, K through Ph.D.

### **Longitude and Latitude for APRS/GPS Users:**

#### **Marion's Piazza Beaver Creek**

39 deg 43' 35.6" N  
84 deg 03' 21.8" W

#### **Amber Rose**

39 deg 46' 54.8" N  
84 deg 09' 29.4" W

#### **Hara Arena Complex**

39 deg 49.223' N  
84 deg 15.335' W



### **AMSAT scenes from Dayton 2005**



photo by K3IO

Gould, WA4SXM (at left), Jim, N3YDT, and a number of other AMSAT volunteers man the 2005 booth at the Dayton Hamvention.



# Operating the FM LEO Satellites from Europe using an HT and AL800 Antenna

by Allen Mattis, N5AFV, [n5afv@amsat.org](mailto:n5afv@amsat.org)

## Introduction

A recent business trip to Copenhagen provided me with an opportunity to operate the FM LEO satellites in Europe. The entire trip including travel took slightly less than four days. Other satellite operators told me that the FM birds are very congested over Europe and that it would be difficult to make contacts with an HT and AL800, but I was looking forward to the challenge. The experience I gained operating the FM LEO satellites on this trip allows me to make some comparisons between operating on the FM satellites in the United States versus operating on them in Europe.

## Operating Conditions

The operating conditions on this trip were not the most favorable. My choice of equipment was my usual Icom W32A HT with an AL800 telescoping antenna. Since I was traveling light and not checking any baggage, I did not take along any back up equipment except for an MFJ-1717 antenna in case my AL800 antenna was confiscated by airport security, or damaged. The AL800 antenna was examined very carefully by airport security personnel in Frankfurt, Germany, but after explaining that it was an antenna for the radio that was packed with it, I was allowed to carry the AL800 onto the airplane.

I did not take any type of battery charger with me. My battery chargers would not work in Europe without adapters, so I took along three fully charged batteries. I can usually work eight to ten satellite passes on one battery, and since I would only be in Copenhagen for less than 48 hours, I felt that the three batteries would last for the entire visit.

The weather conditions in Copenhagen were challenging. The temperature range was

32 to 45 degrees F (0 to 7 degrees C) with frequent light to moderate rain occasionally mixed with snow. It was actually a little exhilarating for me to work a station while snowflakes were hitting my face.

## Summary of Contacts

While in Copenhagen I was able to operate on all three currently active FM satellites (AO-27, SO-50 and AO-51). I attempted to work 21 different passes and made a total of 28 contacts (Figure 1).

As I had been told to expect, it is more difficult to make contacts on the FM satellites from Europe than from the United States. Observations I made while working 21 different passes provide a basis for comparing operation on the FM LEO birds in Europe versus in the United States (Figure 2).

Because the FM LEO satellites each have their own characteristics and related performance, each satellite will be discussed separately. I was able to operate multiple passes of each satellite and make observations about how operating conditions vary from what we experience in the United States.

## AO-27

The analog repeater on AO-27 is programmed to turn on for a six-minute window while passing over the central third of the Northern Hemisphere. In the southern United States we hear 20 seconds of beginning telemetry, six minutes of repeater operation and a final 60 seconds of telemetry. On two AO-27 passes that I attempted to work from Copenhagen the bird was in the final telemetry stage when I had AOS. Copenhagen is at the same approximate latitude as Juneau, AK, and the six-minute window is already over on lower elevation passes when the bird comes up over the horizon. On higher elevation passes, I heard approximately 2 ½ minutes

of the six-minute window before onset of the final telemetry. Many European stations are waiting for AOS and immediately start calling when they hear the downlink. This results in tremendous congestion and only a few powerful stations get through. The congestion is heavier than we have in the United States on holiday weekend passes of AO-51. However, I did manage to make one contact under those conditions.

On the last pass of AO-27 that I worked from Copenhagen there was no congestion. I heard three other stations on that pass and was able to work all of them. Similar to what we have in the United States there were also a number of terrestrial stations that did not appear to know that they were operating on a satellite uplink frequency. Due to the heavy congestion on the other AO-27 passes, I had not been able to hear these stations and the resulting QRM.

## SO-50

In the United States we know that SO-50 is the most difficult of the FM birds to hear because its downlink only runs 250mw. For that reason many of the satellite operators in the United States avoid operating on SO-50. On the first SO-50 pass I tried to work from Copenhagen I could hear myself in the downlink but no one else was on the bird. I had it all to myself! This also happens from time to time in the United States. On later SO-50 passes I heard a number of other stations, but whenever someone would key up with a 67.0 Hz tone, the repeater would drop their signal in a few seconds because a stronger signal without the 67.0 Hz tone would cover them up. This situation makes it difficult to complete contacts, but eventually some stations manage to do so.

I was able to make a fair number of contacts on SO-50. The QRM was not as bad on some passes and operation on SO-50 at these times was not much different than in the United States. I did have a pleasant surprise on one west pass when I heard Mark, VO1ONE, just as I had AOS. Two Spanish stations were trying to work Mark and I was not able to get through, but it was very nice to hear a familiar call sign so far from home. After a minute or so Mark was out of the footprint and I was not able to make any contacts on that pass.

| Satellite | Number of Passes | Number of Contacts |
|-----------|------------------|--------------------|
| AO-27     | 6                | 4                  |
| SO-50     | 11               | 12                 |
| AO-51     | 21               | 12                 |
| Totals    | 21               | 28                 |

Figure 1: Satellite Passes and Contacts worked by OZ/N5AFV, April 3-4, 2006, Copenhagen



| Date     | UTC  | Satellite | Elevation | Contacts | Comments                                                             |
|----------|------|-----------|-----------|----------|----------------------------------------------------------------------|
| 3-Apr-06 | 1302 | AO-27     | 21        | 0        | Ending telemetry heard at AOS                                        |
| 3-Apr-06 | 1440 | AO-27     | 86        | 0        | Very congested, 2.5 minutes of repeater followed by ending telemetry |
| 3-Apr-06 | 1621 | AO-27     | 20        | 0        | Very congested, 2 minutes of repeater followed by ending telemetry   |
| 4-Apr-06 | 1234 | AO-27     | 12        | 0        | Ending telemetry heard at AOS                                        |
| 4-Apr-06 | 1412 | AO-27     | 12        | 1        | Very congested, 1.5 minutes of repeater followed by ending telemetry |
| 4-Apr-06 | 1552 | AO-27     | 30        | 3        | 2 minutes of repeater followed by ending telemetry, 3 stations heard |
| 3-Apr-06 | 1107 | SO-50     | 51        | 0        | Alone on bird, could hear myself in downlink                         |
| 3-Apr-06 | 1248 | SO-50     | 49        | 1        | 3 or 4 stations heard                                                |
| 3-Apr-06 | 1430 | SO-50     | 29        | 1        | 1 station heard                                                      |
| 3-Apr-06 | 1612 | SO-50     | 34        | 3        | 4 or 5 stations heard                                                |
| 3-Apr-06 | 1753 | SO-50     | 88        | 3        | 5 or 6 stations heard                                                |
| 3-Apr-06 | 1934 | SO-50     | 22        | 0        | 2 stations heard, QRM from terrestrial stations and dead carrier     |
| 4-Apr-06 | 1137 | SO-50     | 88        | 1        | 3 stations heard, dead carrier QRM                                   |
| 4-Apr-06 | 1318 | SO-50     | 35        | 0        | VO1ONE call sign heard at AOS, 3 stations heard on pass, heavy QRM   |
| 4-Apr-06 | 1500 | SO-50     | 28        | 2        | 2 stations heard                                                     |
| 4-Apr-06 | 1642 | SO-50     | 48        | 1        | 2 stations heard, snow was falling while I worked the pass           |
| 4-Apr-06 | 1823 | SO-50     | 50        | 0        | 5 stations heard, dead carrier QRM                                   |
| 3-Apr-06 | 1816 | AO-51     | 30        | 4        | Very congested, many stations heard, made contacts near end of pass  |
| 3-Apr-06 | 1955 | AO-51     | 52        | 2        | Extremely congested and difficult to get in with HT & AL800          |
| 4-Apr-06 | 1738 | AO-51     | 18        | 2        | Very congested until bird moved farther north                        |
| 4-Apr-06 | 1915 | AO-51     | 79        | 4        | Congested, many stations heard, made contacts near end of pass       |

**Figure 2: Satellite Passes worked by OZ/N5AFV, April 3-4, 2006, Copenhagen**

## AO-51

The congestion I observed on AO-51 did not appear to be as heavy as what I experienced on AO-27. This probably results from having the full pass to operate on the satellite instead of just a portion of the AO-27 six-minute window. I operated four passes of AO-51 and made contacts on all of them. I made four contacts on each of two passes of AO-51. When I use my HT and AL800 in the United States, I usually average five contacts on an AO-51 pass, so I did not make as many contacts in Copenhagen as I usually do in the United States.

### Contributing Factors

A number of factors negatively affected my ability to make contacts in Copenhagen. First of all, the number of call sign prefixes that you will hear on a LEO satellite pass in Europe is significantly greater than what

you will hear on LEO satellite passes in the United States. I worked eleven different DXCC entities in the 28 contacts I made. Because a number of the letter combinations in the prefixes were unfamiliar to me, I had difficulty copying some of the call signs the first time I heard them. This negatively affected the number of contacts I was able to make. Secondly, while almost all of the operators spoke English, some of the accents were very heavy and that also made it difficult for me to understand some of the operators. By the end of my satellite operation in Copenhagen, however, I was clearly copying the call signs more easily and understanding the operators better.

Another difference between working the FM LEO satellites in Europe versus the United States is that the Europeans make a full exchange during the contact. The complete

six-digit grid square identifier is exchanged as well as a signal report. In the United States we usually only exchange a four-digit grid square identifier and, because the signal we copy is really the satellite repeater and not the station we are working, we usually do not give a signal report. The longer time that it takes to pass this additional exchange in Europe adds to the congestion on the satellites.

### Conclusions

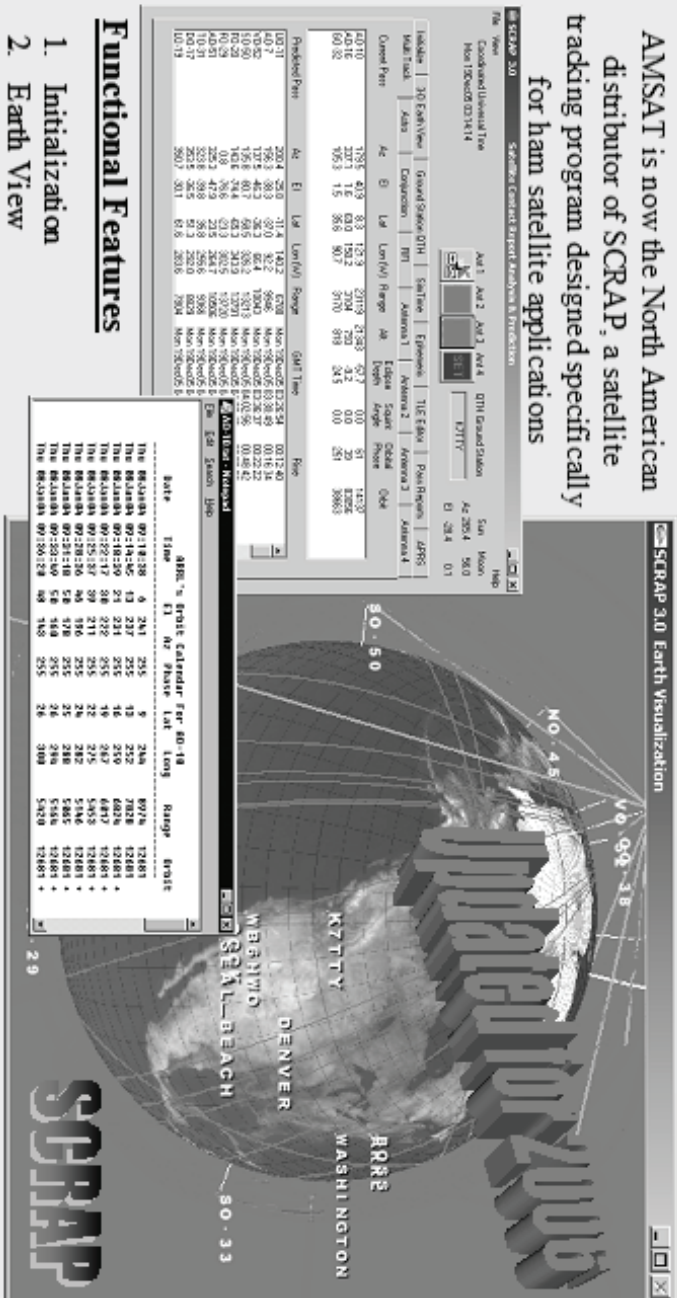
Operating on the FM LEO satellites in Europe was very exciting and I worked a number of the active European satellite operators. When they heard that I was standing out in the rain in near-freezing temperatures using an HT with a telescoping antenna they went out of their way to make me feel welcome. I always enjoy making new friends through our hobby of Amateur Radio. ☺





# Satellite Contact Report Analysis Prediction 3.0

AMSAT is now the North American distributor of SCRAP, a satellite tracking program designed specifically for ham satellite applications



## Performance Features

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2. Earth View
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5. Ephemeris
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7. Pass Reports
8. APRS display
9. Multi-Track display
10. Four Ant rotor controllers
11. Astronomical prediction
12. Satellite Conjunctions
13. Radio Frequency Interference

## Recommend minimum processor

1. Windows 98 or better
2. Pentium Processor 500 MHz or greater
3. 256 MBytes RAM
4. Graphics accelerator card desired
5. 1024 x 767 resolution recommended

**SCRAP**

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Bytheway Software Development Lab (BSDL)

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## AMSAT Appoints Director of Education

AMSAT is very pleased to announce that Dr. H. Paul Shuch, N6TX, has agreed to accept the position of Director of Education. Paul, who received his Ph.D. from the University of California, Berkeley, brings to the AMSAT External Relations Team an extensive background in teaching, curriculum development, communications, and engineering.

Paul's highest priority as Director of Education will be integrated curriculum development at all levels (K through PhD), with emphasis on using satellites in the classroom, to enhance the teaching of science, math, geography, social studies, technology and the social sciences. To accomplish this, Paul will be polling the membership (initially through an article in the Journal) to ascertain what resources and expertise already exists. Paul explained, "I would then invite all teachers within AMSAT to share with me their current, past or planned use of satellites in the classroom, their instructional materials and their desires in terms of future curricular development." Based on his knowledge of the educational system, Paul has already identified one key aspect of doing anything in the educational arena: a need for those efforts to be tied to the federal No Child Left Behind act, as well as the published educational competencies and graduation standards established by the various states. Paul expects to work together with other AMSAT educators to evaluate the competencies and standards in force in their individual states, so that our curriculum can tie in to them to the greatest possible extent.

One area in which AMSAT already has a rich history of educational activities is human spaceflight, most recently through the ARISS Program. Paul states, "I would not presume to modify these existing programs in any way. However, ARISS contacts should not be an end unto themselves." ARISS generates a great deal of enthusiasm leading up to a contact with the astronauts on the International Space Station. Coordinating closely with Frank Bauer, AMSAT VP Human Spaceflight, Paul will be seeking ways we can encourage ARISS schools and teachers to take the next step, with programs to leverage that enthusiasm into an ongoing interest in math, science and Amateur Radio.

## 2006 AO-51 Field Day Configuration

Mike Kingery, KE4AZN, [ke4azn@amsat.org](mailto:ke4azn@amsat.org)

### AO-51 Command Station

This year, AO-51 will be set up in dual FM repeater mode allowing for two usable FM repeaters from the satellite. The FM repeater utilizing the transmitter on 435.300 will be open to all users. The FM repeater utilizing the transmitter on 435.150 (normally reserved for BBS operations) will be reserved during Field Day for QRP stations only, as has been the common practice when this mode runs on AO-51. Please note the information on the mode configurations and QRP requirements.

### FM Repeater #1 for all Users:

Downlink: 435.300 MHz FM

Uplink: 145.920 MHz FM

### FM Repeater #2 for QRP Users ONLY:

Downlink: 435.150 MHz FM

Uplink: 145.880 MHz FM

### AO-51 Echo Low Power Station (QRP) Requirements:

To attempt to keep this simple, a low power station will be defined as a station which can deliver no more than 10 watts to a vertical or handheld antenna. These are some examples of Low Power Stations:

Using an HT (barefoot, no amplifier) with 10 watts or less output into any type of vertical whip antenna (rubber duck, etc) or handheld beam antenna (Arrow type).

1. Using a mobile station with 10 watts or less output into car mounted mobile whip antenna(s).
2. Using a base station at 10 watts output into a vertical omni-directional antenna on the side of the house.

Examples that are NOT Low Power Stations:

1. Any type of high gain beam antenna, KLM, M2, Cushcraft, etc.
2. Any station transmitting over 10 watts into any type of antenna.

Another key area of attention for Paul as Director of Education will be Cubesats. Paul notes "There is a definite educational mission in satellite construction, which goes far beyond the production and launch of a payload." Paul is seeking to find a way to get satellite builders talking to satellite users, in an educational setting. Paul explains, "It is my hope that by finding specific educational applications of existing and planned small satellites and by providing proper training to satellite developers, we will get them fired up about supporting the classroom use of their creations."

Executive Vice President of AMSAT and External Relations team leader Lee McLamb, KU4OS, said, "I am very excited that with Paul we've found such a talented and motivated person to serve as AMSAT Director of Education". Lee continued, "Our educational efforts have not always had someone with Paul's background to

help focus the effort to get the best possible results. I'm sure that as Paul develops his educational team, AMSAT, students, and the entire educational community will benefit in ways we haven't yet imagined."

(Please see the article by Paul on page 12 of this issue of *The AMSAT Journal* – Ed.)



**amsat.org**



## 2006 AMSAT Field Day Competition

by Bruce Paige, KK5DO, [kk5do@amsat.org](mailto:kk5do@amsat.org)

It's that time of year again; summer and Field Day! Each year the American Radio Relay League (ARRL) sponsors Field Day as an emergency preparedness exercise. The event takes place during a 24-hour period on the fourth weekend of June. For 2006 the event takes place during a 27-hour period on the fourth full weekend of June, from 1800 UTC on Saturday June 24, 2006 through 2100 UTC on Sunday June 25, 2006. Those who set up prior to 1800 UTC on June 25 can operate only 24 hours. The Radio Amateur Satellite Corporation (AMSAT) promotes its own version of Field Day for operation via the amateur satellites, held concurrently with the ARRL event.

If you are considering ONLY the FM voice satellites like AMRAD-OSCAR-27, SaudiSat-Oscar-50 or AMSAT-OSCAR-51 for your AMSAT Field Day focus, don't, unless you are simply hoping to make one contact for the ARRL rules bonus points. The congestion on FM LEO satellites was so intense in 2005 that we must continue to limit their use to one-QSO-per-FM-satellite. This includes the International Space Station. You will be allowed one QSO if the ISS is operating voice. You will also be allowed one digital QSO with the ISS or any other digital, non-store-and-forward, packet satellite (if operational).

The format for the message exchange on the ISS or other digital packet satellite is an unproto packet to the other station (3-way exchange required) with all the same information as normally exchanged for ARRL Field Day, e.g.:

W6NWG de KK5DO 2A STX  
KK5DO de W6NWG QSL 5A SDG  
W6NWG de KK5DO QSL

If you have worked the satellites on Field Day in recent years, you may have noticed a lot of good contacts can be made on some of the less-populated, low-earth-orbit satellites like Fuji-OSCAR 29 or AMSAT-OSCAR 7. During Field Day the transponders come alive like 20 meters on a weekend. The good news is that the transponders on these satellites will support multiple simultaneous contacts. The bad news is that you can't use FM, just low duty-cycle modes like SSB and CW.

**The 2006 AMSAT Field Day Rules**

The AMSAT Field Day 2005 event is open to

all Amateur Radio operators. Amateurs are to use the exchange as specified in ARRL rules for Field Day. The AMSAT competition is to encourage the use of all amateur satellites, both analog and digital. Note that no points will be credited for any contacts beyond the ONE allowed via each single-channel FM satellite. Operators are encouraged not to make any extra contacts via these satellites (Ex: AO-27 & SO-50). CW contacts and digital contacts are worth three points as outlined below.

**1. Analog Transponders**

ARRL rules apply, except:

- Each phone, CW, and digital segment ON EACH SATELLITE TRANSPONDER is considered to be a separate band.
- CW and digital (RTTY, PSK-31, etc.) contacts count THREE points each.
- Only one contact is allowed via each single-channel FM satellite, AO-27 (1 phone), SO-41 (1 phone), SO-50 (1 phone), AO-51 (1 phone regardless of mode; PBBS-see Pacsats below), ISS (1 phone and 1 digital), PCSat (I, II, etc.) (1 digital), etc.
- The use of more than one transmitter at the same time on a single satellite transponder is prohibited.

**2. Digital Transponders**

For the Pacsats (GO-32, AO-51) or 'Store and Forward' hamsats, each satellite is considered a separate band. Do not post "CQ" messages. Simply upload ONE greeting message to each satellite and download as many greeting messages as possible from each satellite. The subject of the uploaded file should be posted as Field Day Greetings, addressed to ALL. The purpose of this portion of the competition is to demonstrate digital satellite communications to other Field Day participants and observers. Do not reply to the Field Day Greetings addressed to ALL.

The following uploads and downloads count as three-point digital contacts.

- (a) Upload of a satellite Field Day Greetings file (one per satellite).
  - (b) Download of Satellite Field Day Greetings files posted by other stations.
- Downloads of non-Field Day files or

messages not addressed to ALL are not to be counted for the event. Save DIR listings and message files for later "proof of contact."

Please note AMSAT uploaded messages do not count for QSO points under the ARRL rules.

Satellite digipeat QSO's and APRS short-message contacts are worth three points each, but must be complete verified two-way exchanges. Remember, only one digipeat contact is allowed for the ISS and other satellites in this mode. The use of terrestrial gateway stations or Internet gateways (i.e. EchoLink, etc.) to uplink/downlink is not allowed.

**Sample Satellite Field Day Greetings File**

"Greetings from W5MSQ Field Day Satellite station near Katy, Texas, with 20 participants, operating class 2A, in the AMSAT-Houston group with the Houston Amateur Television Society and the Houston QRP club. All the best and 73!"

Note that the message stated the call, name of the group, operating class, where they were located (the grid square would be helpful) and how many operators were in attendance.

**3. Operating Class**

Stations operating portable and using emergency power (as per ARRL Field Day rules) are in a separate operating class from those at home connected to commercial power. On the report form simply check off Emergency or Commercial for the Power Source and be sure to specify your ARRL operating class (2A, 1C, etc.).

**And Finally...**

The Satellite Summary Sheet should be used for submission of the AMSAT Field Day competition and be received by KK5DO (email or postal mail) by 11:59 P.M. CDT, Monday, July 17, 2006. The preferred method for submitting your log is via e-mail to [kk5do@amsat.org](mailto:kk5do@amsat.org) or [kk5do@arrl.net](mailto:kk5do@arrl.net). You may also use the postal service but give plenty of time for your results to arrive by the submission date. Add photographs or other interesting information so that can be used as an article for the Journal.

You will receive an e-mail back (within one or two days) from me when I receive your





e-mail submission. If you do not receive a confirmation message, then I have not received your submission. Try sending it again or send it to my other e-mail address.

If mailing your submission, the address is:

Bruce Paige, KK5DO  
Director of Awards and Contests  
PO Box 310  
Alief, TX 77411-0310.

The first-place emergency power/portable station will receive a certificate at the AMSAT General Meeting and Space Symposium in San Francisco, California, October 6-7, 2006. Certificates will be awarded for second and third place portable/emergency operation in addition to a certificate for the first-place home station running on emergency power. Stations submitting high, award-winning scores will be requested to send in dupe sheets for analog contacts and message listings for digital downloads.

You may have multiple rig difficulties, antenna failures, computer glitches, generator disasters, tropical storms and there may even be satellite problems, but the goal is to test your ability to operate in an emergency situation. Try different gear. Demonstrate satellite operations to hams that don't even know the HAMSATS exist. Test your equipment. Avoid making more than ONE contact via the FM-only voice HAMSATS or the ISS, and enjoy the event! 📡

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This form is designed to allow easy editing in a word processor.

AMSAT Satellite Summary Sheet - 2005

Satellite and number of Voice QSO's

AO-27 1 (example)

Satellite and number of CW/RTTY/PSK31 etc QSO's

FO-29 5 (example)

Satellite and Up/Downloads

UO11 3 (example)

Score Calculation

Total Voice QSO's x 1 =

Total CW/RTTY/PSK31 QSO's x 3 =

Total Up/Downloads x 3 =

Grand Total =

Please provide the following information:

Your Field Day Callsign

Your Group Name

ARRL Field Day Classification

ARRL Section

Power Source (Select 1)

Emergency

Commercial

Your name and home call

Home address

Any Comments

## Thank You from KC5ACR on ISS

To the Amateur Radio Community,

As Expedition 12 draws to a close on board the International Space Station, a note of gratitude is due.

I would like to express my deep gratitude to the worldwide Amateur Radio community for your participation in this great adventure. Clearly, one of the benefits for Amateur Radio is bridging the distances between us. Through your participation, you helped realize the potential for the human exploration of space to do exactly that. Thanks to you, over the past six months, the International Space Station has been more international than ever before. Together, we achieved many significant milestones from space,

DXCC, WAC, WAS and most importantly, 35 school contacts (as of March 21).

Special thanks go to Kenneth Ransom, N5VHO, without whose tireless efforts to coordinate our activities onboard none of this could have been achieved. Kenneth provided invaluable technical advice, as well as raising the bar as each goal was achieved. I would also like to thank the ISS Fan Club for your enthusiastic support of ARISS. And personal thanks to Cor, PD0RKC, in The Netherlands, Alain, IZ6BYY, in Italy, Keith, ZS6TW, in S. Africa and Patrick, WD9EWK, in Arizona for enlisting the participation of the stations we needed to meet the goals for Expedition 12.

It is with no small degree of sadness to realize that soon I will no longer be able to float to the aft part of the station, dial up our frequency pair and call "CQ", knowing that a host of friends are waiting to talk. Good luck to you all. Thank you, again, for your participation in this greatest of all human endeavors. I look forward to listening as you continue your enthusiastic support of the International Space Station and, one day, human colonies on the Moon and Mars.

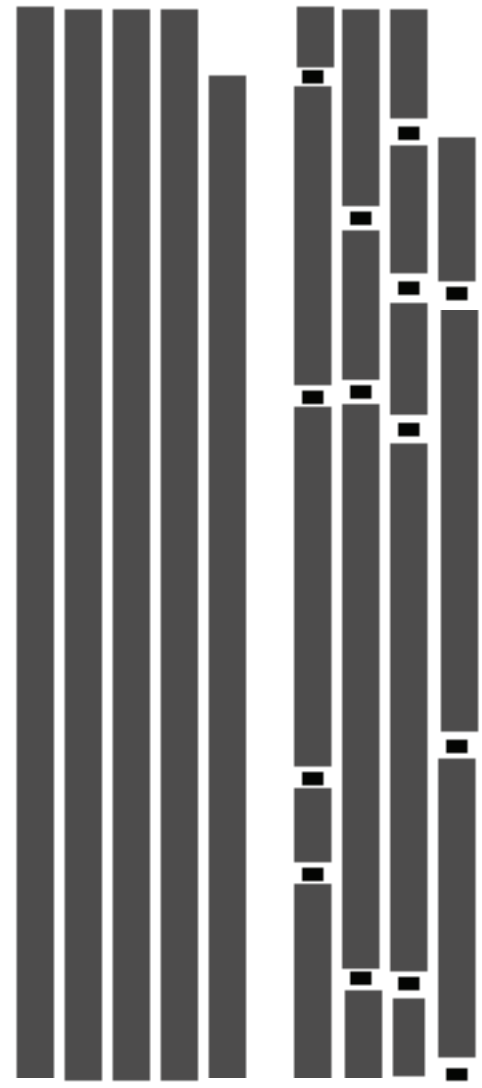
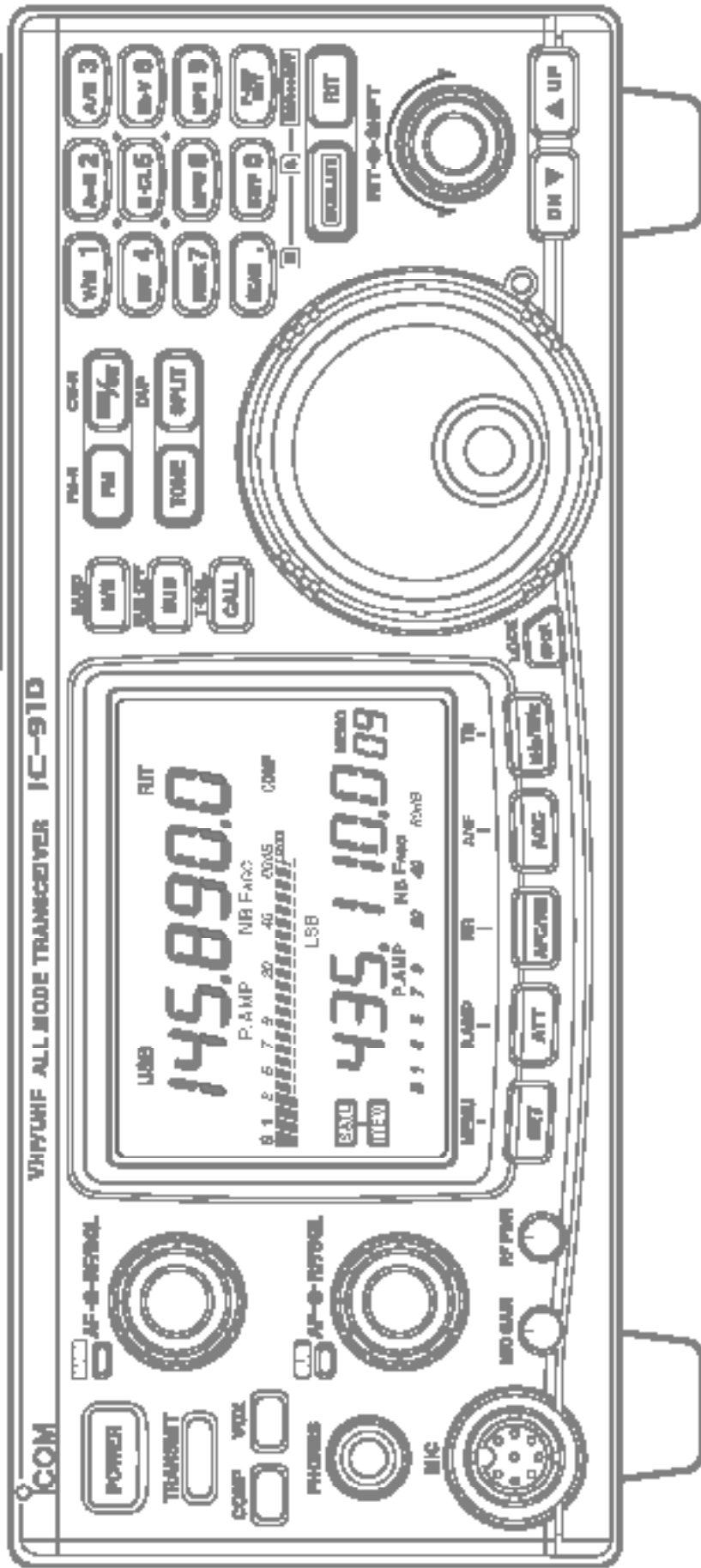
73 de NA1SS

Bill McArthur, KC5ACR

Commander, Expedition 12

International Space Station 📡





ICOM